
MACHINE DESIGN
March 1942
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MACHINE DESIGN

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Itemized Index

Classified for Convenience when Studying Specific Design Problems

MACHINE DESIGN is indexed in Industrial Arts Index and Engineering Index Service, both available in libraries generally.

Topics

SELF-DOUSING lights for blackouts at unattended locations have been proposed for protection during air raid alarms. Small, inexpensive radio receivers tuned to the carrier wave of a nearby radio station would disconnect the light when the station goes off the air during a blackout.

ELECTROGRAPHIC analysis for qualitative examination of metals without injury to them has been reported by the Bell Telephone Laboratories. The method is simple and rapid and the equipment is cheap. Permanent records are produced which may serve for future reference. Extremely small quantity of the metal is carried into a solution of a salt, alkali or acid by electrolysis and is spot tested for constituency. For instance, potassium cyanide shows blue for iron or brown for copper, a sulphide gives a dark brown in the presence of copper or lead, and dimethyl glyoxime makes a red color with nickel. Other reagents give distinctive colors for additional metals.

OF PRIME importance to all engineering departments is the conversion program now under way for making available the capacities and facilities of all possible machinery manufacturing companies for war production. Donald Nelson, WPB Chairman, has asked for conversion and still more and faster conversion of industry. Indicative of the resourcefulness of engineers to meet this demand is the changeover of a merry-go-round manufacturer to design and make airplane parts for pursuit ships and bombers. Besides planning of the job and reschooling of employes, complete changeover from ordinary machines and structures to the highest type of precision work was involved.

RECENTLY the War Department defined the difference between *critical* and *strategic* when applied to materials used in war equipment. Critical materials are those available in this country but in insufficient quantities to meet needs, whereas strategic materials are those which must be imported. This distinction between words previously used so freely and interchangeably will no doubt eliminate considerable confusion in referring to materials involved in the war program.

SILVER uses for current-carrying parts are increasing rapidly. Unavailability of copper for bus bars and other electrical parts points to this precious metal both because it is an excellent conductor and is available from reserves, and from newly mined sources. In powder metallurgy silver is mechanically mixed with metals, such as nickel, which do not alloy except in small proportions. Graphite, tantalum, molybdenum and tungsten are among the materials mixed in powder form with silver, compressed and sintered at a temperature slightly below the melting point of silver. Some resulting products can be rolled into sheet or drawn into rod. Being a precious metal, silver and its alloys are usually overlooked by designers. Its cost is less than tungsten, molybdenum, beryllium or sintered carbides.

PURIFIED, stable chlorinated rubber, called Parlon, is nonflammable in dried film. In speed of drying it approaches lacquer and for resistance to moisture is one of the most highly impermeable films known. It is little affected by acids, alkalis and petroleum products, making it especially useful for protective coatings.

UNION of South Africa has recognized the importance of arc welding by issuing stamps depicting a welder using electric arc equipment. Probably the first time postage stamps have been issued as a tribute to welding, they indicate that the Union is not lagging behind other countries.

SYNTHETIC resin-bonded plywood is now forming the basic material for prefabricated houses to help solve quickly the housing shortage throughout the country. Economical use of wood and relatively small quantities of resins make this method of construction particularly useful.

MACHINE DESIGN

Facing the Facts

By Donald M. Nelson*

WE AS a nation are engaged in a grim struggle, pitting our inventive genius and our production ability against a determined and altogether too able adversary. It is trite to say that this war will be won on the production lines. Wars are *always* won by having more and better materiel than the enemy. Incidentally, let us not lose sight of the fact that second place in a war with Nazism is a fearful thing to think about. Our nation has said in no uncertain terms that it does not want to be second to any possible combination of enemies headed by Hitler.

That puts the job of rearming up to us and we have a stupendous job to do—a job that staggers the imagination. In ordinary times, the man who is responsible for bringing out new equipment does not make the saving of material a primary consideration. He concerns himself with the appearance, decoration and finish, efficiency of performance, durability, and ease of manufacture. He is of course anxious not to waste material, because waste is costly; but he does not sit down to his job

*Mr. Nelson delivered the address abstracted in this article before the recent A.S.M.E. annual meeting.

with that idea of saving material uppermost in his mind. Materials have always been plentiful in this country. During the last decade there have been times when they seemed too plentiful for our own economic good. The present emergency, however, has drastically changed all of that.

Risks involved in trying out new ways and means of making things are necessarily high during this emergency. They are high because time is one of the innumerable things of which we do not have enough. Ordinarily, when a new design or a new process is introduced one has a chance to try it out. The trial period brings out the kinks; they are ironed out and it is tried again. In other words, a certain period for trial-and-error testing is available. In this emergency that period just doesn't exist. The thing has got to click from the start. In the second place, the product will probably face a stiffer test than it faces in ordinary times. That certainly is true of anything for military use.

Tests Our Mechanical Prowess

So it adds up to a hard job. Yet it is not an impossible one. There is good reason to believe that in other countries the necessary reorientation in attitude toward the use of materials has already gone far. Great Britain, Germany and Russia have provided numerous and often surprising results from their attempts to effect both a saving of materials and a maintenance or even an increase in the efficiency of functioning. It is clear that readjustments must be made on an ever-increasing scale; and while it unquestionably is true that in many cases both durability and efficiency must suffer, it remains a fact that the degree to which American engineering and inventive genius can succeed in maintaining standards of quality will constitute one of the tests of our mechanical prowess as a producing nation.

The most sensible way to discuss this question of the greatest possible utilization of materials is to approach it from the design viewpoint. Thus we can restate the problem in general terms about as follows: How can we best bring to focus upon the desks of our engineers and designers every available bit of scientific knowledge, and the imaginative application of that knowledge?

Government Sources Can Help

With the rapid progress of scientific research, I venture to believe that there are innumerable opportunities for new combinations of materials and new applications of knowledge which can be worked out to help us, in this major attempt, make the very best possible uses of our available materials so that we can win a war and still keep our economy sound.

This matter has received abundant attention from the government, and the engineer or designer who approaches the problem will find many government sources on which he may draw for help. Both the Army and Navy have conservation sections. The various supply arms and services within the Army make monthly reports of progress to the conservation section, and continuously study specifications which involve strategic and critical materials with a view to revision wherever possible. Each of the supply arms and services has a liaison officer attached to its conservation section.

The Army's interest in conservation, however, is not limited to the internal revision of specifications. Wherever possible its officers help manufacturers to shift their materials and processes so as to permit more efficient use of materials. This is a particularly fertile field in instances where specifications stipulate required performance, rather than all the details of design. The Army also initiates conferences with industry to discuss ways and means of fitting substitute materials into Army procurement programs. For example: The Army Air Corps recently held at Dayton, Ohio, a conference to which it invited members of the plastics industry and representatives of interested government agencies, for the purpose of agreeing on specifications of various plastics. A detailed discussion was had of such things as tension, compression, shear, bearings, fatigue, hardness, durability, and so on, as applicable to plastics; and the meeting succeeded in laying the necessary groundwork for proper comparison and evaluation of the results of research in plastics.

Shell Case Substitution Problems

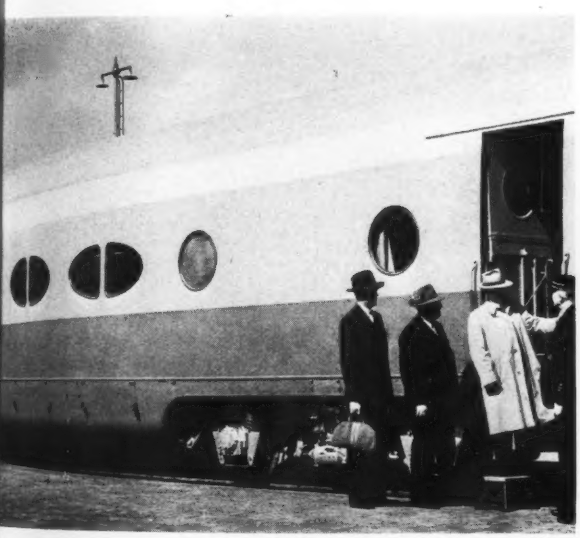
One of the most important projects from the standpoint of our economy has to do with the search for a substitute for brass shell casings. Industry today is suffering from an acute copper shortage due to the huge requirements of defense; and one of the major items in defense requirements is for brass to make shell casings. Forty per cent of our guns are designed for brass shell casings. Substituting steel casings or casings made of any other metal which does not expand and contract at, and immediately after, the moment of explosion precisely as brass expands and contracts, would simply mean either a blown-out breech of the gun or a "frozen" casing which could not be extracted. The Army is working hard to find some substitute for brass—probably a combination of steel and brass—which can be used to replace the present all-brass casings. It is making excellent progress. I believe it will presently find a solution. When that occurs, a great step will have been taken to ease the strain on our copper supply.

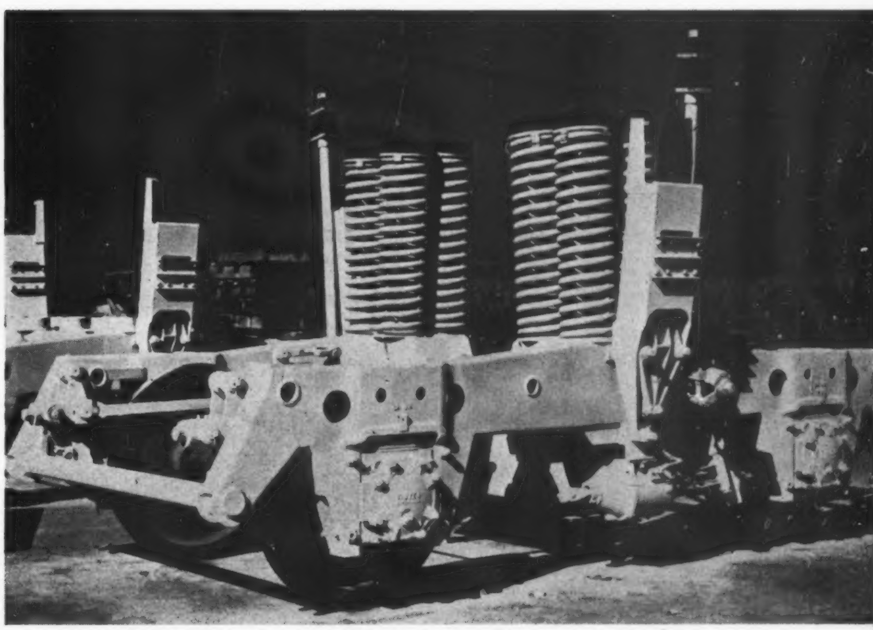
Much has been done in the field of substitution; much of the revision of government specifications falls within this category, and hundreds of speci-

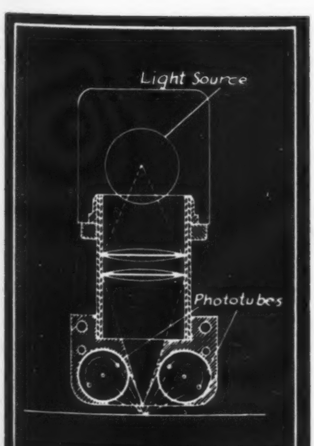
(*Continued on Page* 126)

Scanning the field for IDEAS

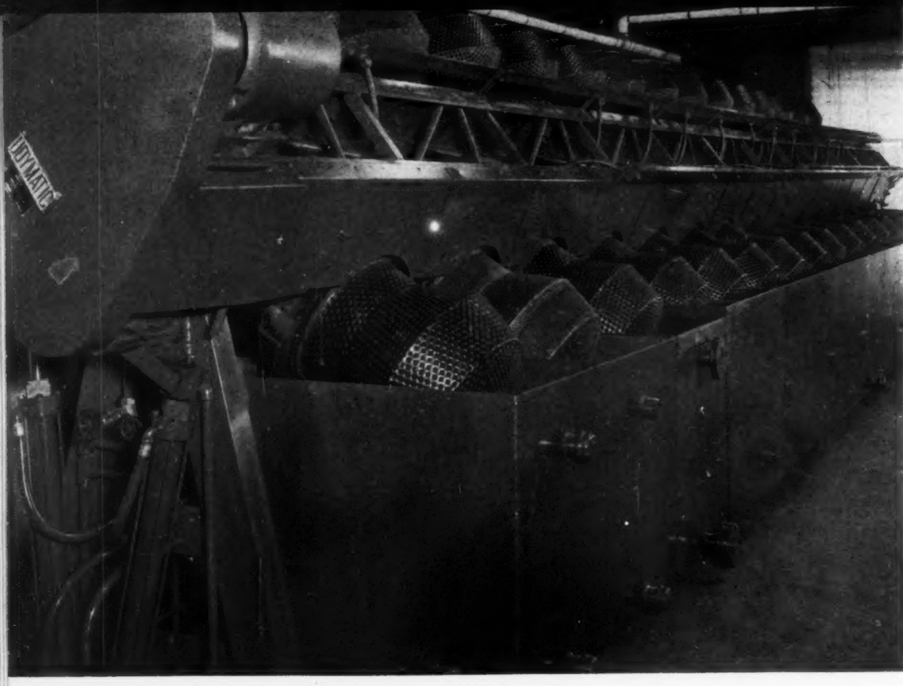
Pendulum suspension for railway coaches supported from the corners well above the center of gravity gives passengers a smooth ride and a sensation of stability by banking against curves at high speeds. Developed some time ago, the suspension is shown in the truck, below, and is now in service on the Santa Fe Railway. Mounting supports are two feet above the center of gravity of the coach and utilize soft coil springs to provide a floating ride. The coach is of "stressed skin" design, a popular construction for modern streamlined trains to provide light weight by eliminating the conventional frame.







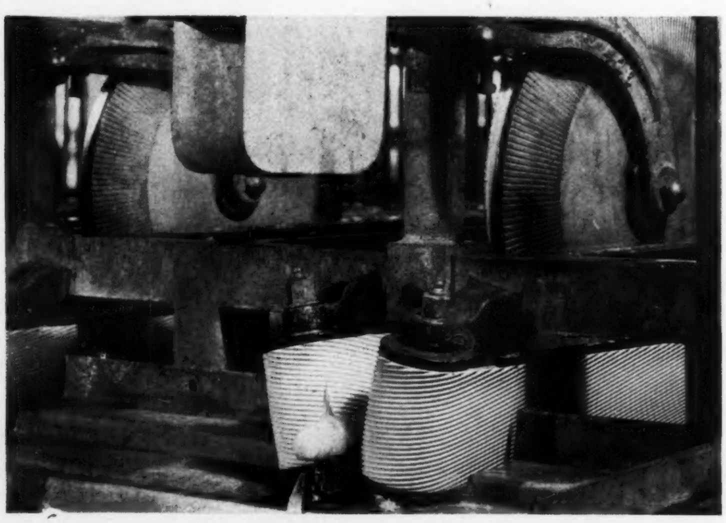
Self-contained phototube scanner at left indicates how the application of a commercial part may be facilitated by compact design. Both light source and phototubes are housed in the unit, obviating separate light source and scanner. Designed by United Cinephone, light passing through a double converging lens system is concentrated on a spot between two tubes. Intensity of reflection, depending on the surface characteristics of the material being scanned, determines the response of the tubes and the auxiliary devices.



Self-contained, this compact radio transmitter and receiver can be handled and used as conveniently as a telephone but with no wires attached. Capable of receiving and transmitting over distances up to one mile with a continuous rating of eight hours or one month of normal intermittent operation the radio, shown below, was developed by the Weldronic Corp. Power supply is from standard battery cells to facilitate maintenance; entire weight is about four pounds.

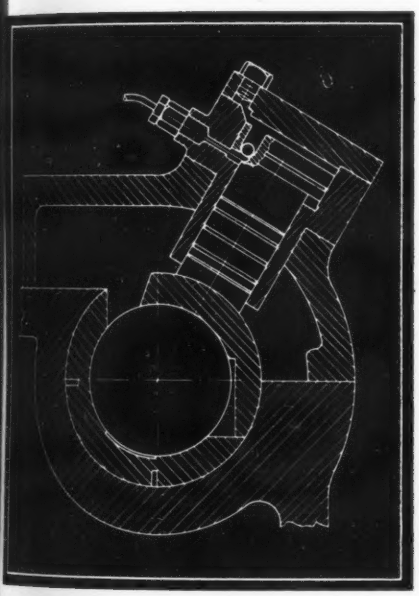
Continuous processing has long been troublesome in the electroplating industry. Conveyors with baskets dipping into progressive tanks have been applied, as has also automatic changing of the electrolyte. Difficulty usually is experienced in attempting to find materials for containers, insulation, tanks and cathodes which will be impervious to the solutions needed. This has given rise to exploring the possibilities of changing the containers for each stage of the process, thus enabling selection of the best materials for each bath. The continuous process machine shown above is the result developed by the Udylite Corp.

Only the parts being plated are transferred progressively from bath to bath in the machine, which has alternately spaced barrels on each side of a horizontally pivoted frame. Barrels are interconnected by a system of cross chutes which transfer the parts for plating from one basket to the next when the frame is tilted. Speed of tilting is sufficiently slow to allow proper draining, preventing contamination of solutions. This process overcomes previous design difficulties and delivers a full charge of plated parts each time the frame is tilted. Solutions and current densities are chosen to allow equal time for each bath.



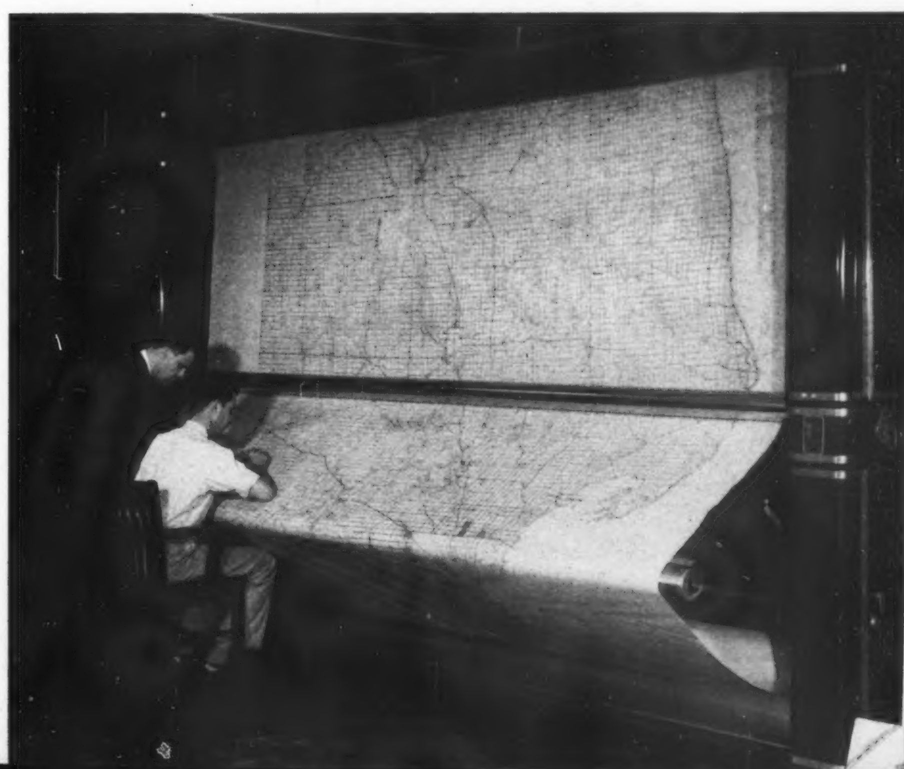
Cleaning shrimp, long considered impracticable by canners, is now economically performed by the machine shown at left. A mass production operation, shrimp in the shell are fed through slots between two diagonally grooved belts which carry them in position over a circular saw. This saw completely removes the alimentary canal of the shrimp heretofore tediously accomplished by hand. Large disks between the belts and above the saw serve to straighten curved shrimp sufficiently and to hold them against the saw. Angle of belts and their grooves in this machine, developed by Goodrich Co., are instrumental in positioning the shrimp.

Precision bearing shown below is hydraulically controlled to increase stability of grinding wheel spindles. Designed by the Churchill Machine Tool Co., England, the bearing utilizes a hydraulic unit of which the piston is in contact with a floating segment of the bearing. A ball check valve gives a ratchet action to the piston, adjusting it downward until the oil film in the bearing is the absolute minimum for stability.



Saving untold hours of time that might otherwise be spent in redrafting, photography is being used increasingly in aircraft plants and other vital plants throughout the country. At the Glenn L. Martin Co., a camera projects full-scale drawings directly on metal or other materials needed for manufacturing operations. In the illustration above are shown fixtures attached to a full scale drawing reproduced photographically on aluminum alloy. This method greatly facilitates fabrication and eliminates costly layout measuring. In addition, full scale drawings obviate the necessity of dimensioning and permit direct printing on metal for machining parts. For development and test, the camera readily gives drawings to any scale desired. During last year, the Martin company estimated their cameras saved the work of 307 able men.

Handling large drawings for viewing, drafting and storing is facilitated with the electrically operated, roller-type case developed by the Motors Metal Manufacturing Co. Front of case may be raised as shown at right for drafting or for alterations. Drawings are wound on large rollers and when not in use are stored in a lower, fireproof compartment. Life of valuable drawings may be multiplied greatly with this method of handling.



High Production Demands A

By A. J. Moore
General Electric Co.

HIGH speeds of modern electric drives often make some form of braking desirable. Such braking is essential where operators may become caught in moving parts, where proper interlocking of the elements of a machine requires split-second timing, and where time, money, and material are lost in processing work if the continuous ribbon of goods breaks.

There are many other instances in which braking is desirable and is a money-saving adjunct to an electric drive. For instance, production from some machine tools can be increased considerably if proper braking stops the spindle at the end of the work cycle rather than allowing it to coast to rest.

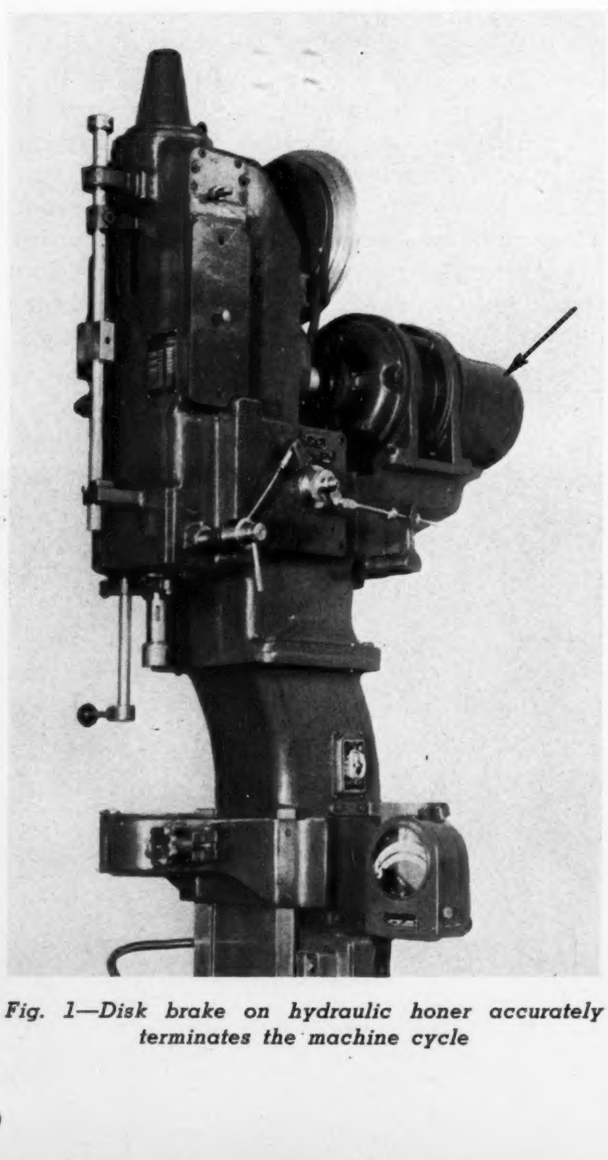


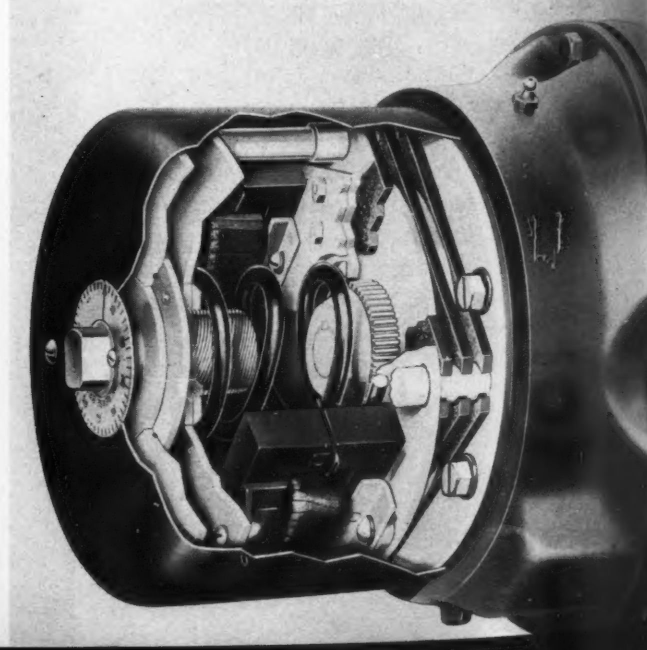
Fig. 1—Disk brake on hydraulic honer accurately terminates the machine cycle

Two fundamental types of braking may be employed for electric drives: One is mechanical-electric, a method of electrically applying a brake to stop the drive mechanically; the other uses the electrical forces inherent in the motor to stop the motion.

MECHANICAL-ELECTRIC BRAKING: One of the most widely used and satisfactory mechanical-electric types is the disk brake which is similar to the clutch structure used in most automobiles except that it is operated by electromagnets incorporated in the brake structure itself. *Fig.* 1 shows a typical application to a honer drive, *Fig.* 2 a cutaway view indicating how such a brake is designed as an integral part of a motor. This brake is inexpensive, simple, compact, and practically dustproof. However, when a brake is totally enclosed, the amount of heat radiation is necessarily limited and it therefore should never be applied on an extremely heavy-duty job.

Not so sleek in appearance is the shoe-type brake illustrated in *Fig.* 3. This ugly duckling redeems itself by its rugged construction and long life. Be-

Fig. 2—Below—Cutaway view of disk brake mounted on a polyphase induction motor



A te Braking

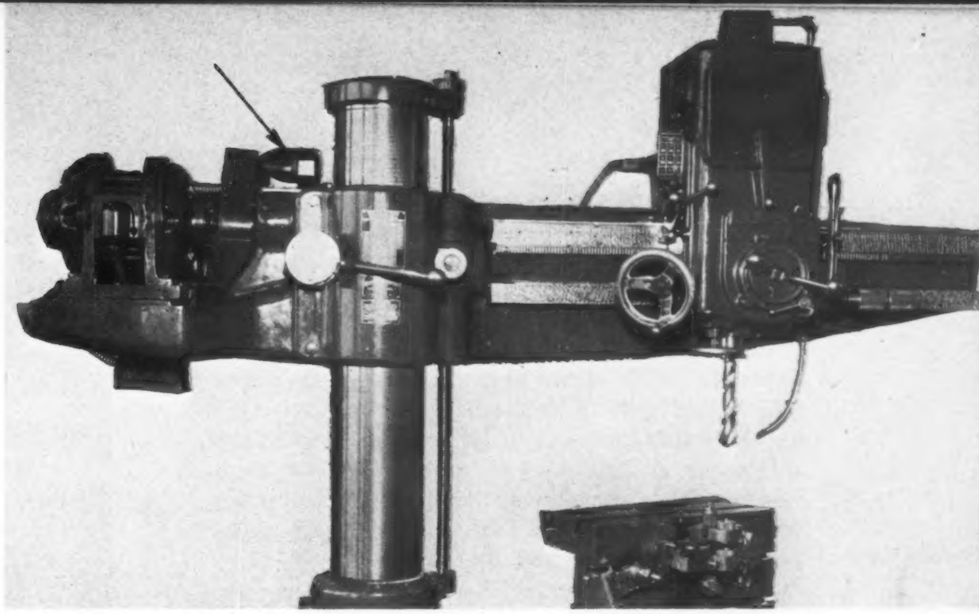
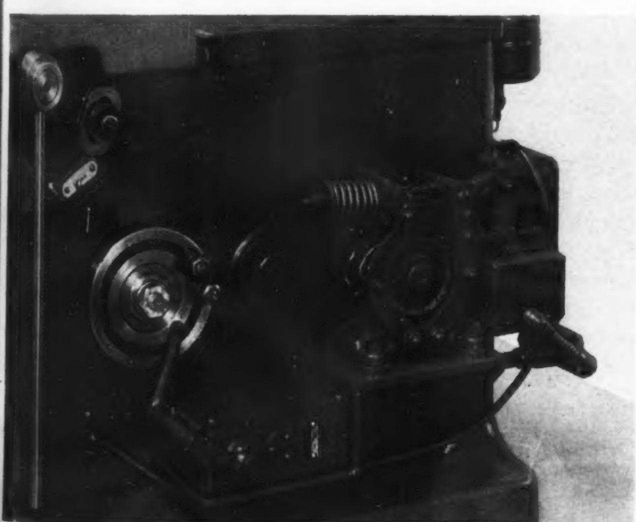


Fig. 4—Above—Stopping in both directions is controlled by plugging switch shown on top of beam and at left of column on radial drill driven by squirrel-cage motor

cause it is open to the air for free ventilation and the brake wheel acts as a fan, heat is readily dissipated. It is available from fractional to high horsepower ratings.

Small shoe brakes are operated by electromagnets or solenoids, large ones usually by thrustors. Where it is desired to stop a machine in the shortest possible time the solenoid type should generally be used; where smoothness of operation and time delay are essential, the thrustor type is ideally suited. Both are reasonably long lived and can withstand severe duty cycles. Any mechanical brake, however, must be adjusted from time to time to compensate for lining wear and eventually the linings must be replaced. The printing press drive in *Fig.* 5 utilizes a thrustor brake for quick, smooth stopping, thus preventing waste of paper in emergency stops.

Fig. 3—Below—Solenoid brake on keyseater shortens reversing time, increases production



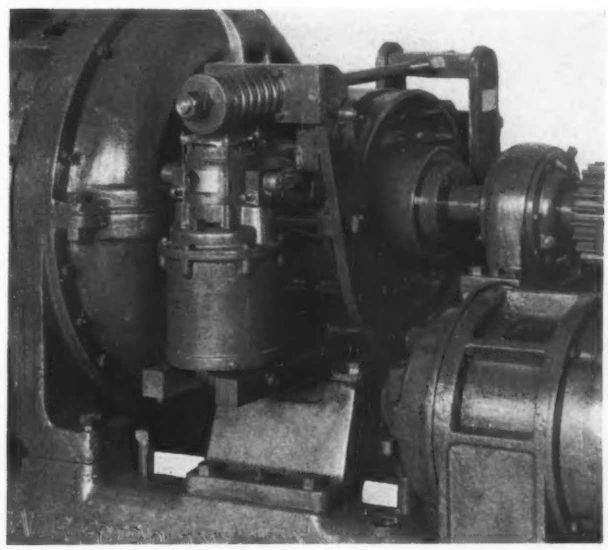


Fig. 5—Both time and material are saved on printing press by thruster brake control

Electric Braking: Where the duty cycle is extremely heavy and severe, where the horsepower involved is large, or where both factors are present, there are several common methods of electric braking. In general these methods possess the advantages of having no parts to wear out and the ability to run indefinitely without adjustment.

Plugging, which is simply the application of power in the reverse-phase direction for the braking cycle, is probably the most common manner of electrically braking a squirrel-cage induction motor. The control usually consists of a magnetic reversing starter which normally would be used to run a motor in either forward or reverse direction. However, to accomplish braking, the reversing contactor is energized with the motor running full speed forward. This causes the motor to exert a torque in the reverse direction and bring itself to rest.

Plugging Relay Cuts Power

Usually automatic power cutoff is desired as soon as the motor reaches zero speed. For this purpose a zero-speed switch or plugging relay is used. *Figs.* 4 and 6 show a plugging relay which utilizes permanent magnets. As can be seen, the rotating shaft which carries the magnet is coupled directly to the

motor shaft and rotates with it.

When the motor is running normally in the forward direction, the magnet causes an aluminum cup which surrounds it to turn slightly and preset a pair of contacts to the closed position so as to maintain power on the motor during the plugging cycle. After the motor comes to complete rest the aluminum cup returns to its normal position, thus opening the relay contacts and removing power from the motor. A double set of contacts is provided in the switch so that it can be used in conjunction with a reversing control to run the motor either forward or reverse, and the motor plug in either direction.

On certain small motor applications where braking time must be extremely short, or where it is not convenient to mount a plugging relay, plugging on a definite time basis is a successful and satisfactory method. Instead of depending on the plugging relay to remove power from the motor during the plugging cycle, a time-delay relay is connected into the control circuit so as to remove power a definite time after the stop button is pressed. Where the inertia of the load remains practically constant and the voltage supply does not vary too widely, the drive can be brought to an exact zero speed within an accuracy of a fraction of a revolution. This method depends for its success on a vacuum-tube timer, used because of its extreme accuracy on short-time cycles. A control of this type is shown in *Fig.* 7.

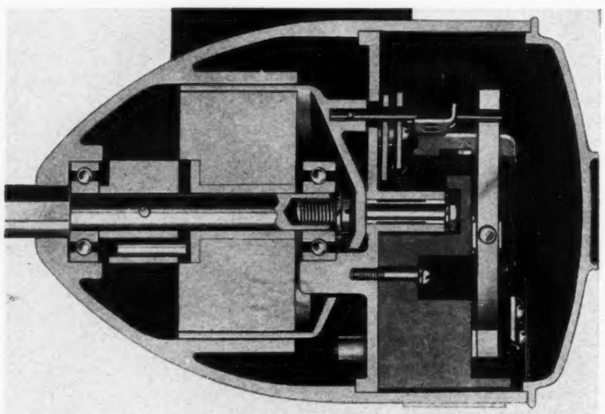


Fig. 6—Longitudinal section of plugging switch utilized in the radial drill shown in Fig. 4

Braking of a polyphase alternating-current motor can also be obtained by applying direct current to its stator during the braking cycle. Voltage must be limited between 10 to 15 per cent of the normal alternating-current voltage. The direct current can be supplied either by an external source or by copper-oxide rectifiers or their equivalent which can be built into the control cabinet for the machine.

A timing relay is included in the control circuit to remove direct current from the motor stator after it has stopped. This timing need not be accurate, but it must have more than the duration required to bring the motor to rest. This method has the distinct advantage of providing electrical braking which will not, under any conditions, reverse the motor. *Fig.* 8 shows the approximate torque curve for this type of braking. While theoretically a high braking torque occurs near zero speed, the results are extremely smooth from a practical standpoint.

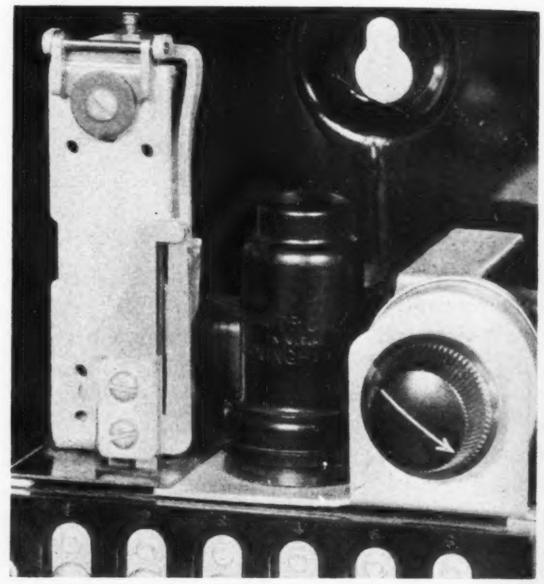


Fig. 7—Where extreme accuracy for short-time cycles is required, the electronic timer can be used to advantage

Somewhat uncommon is the method of connecting a capacitor across the stator of a squirrel-cage induction motor and thus causing it to act as an induction generator. With the capacitor permanently connected, the motor will act as a generator when it is disconnected from the line and hence, in supplying its own losses, will brake itself.

As the size of the capacitor is increased the braking becomes more severe. If a loading resistor is

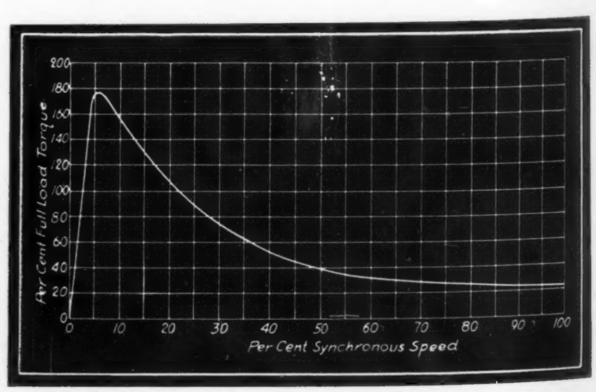


Fig. 8—Typical braking curve of squirrel-cage induction motor with direct current applied to rotor

added, the initial braking torque increases but the shape of the braking curve changes. Fundamentally, however, all braking disappears at about one-third motor speed as shown in the curves illustrated in *Fig.* 9.

In spite of its disadvantages and shortcomings, this type of braking has the outstanding advantages of being self-contained, requiring no auxiliary control relays or equipment. Where the application requires very small motors on heavy reversing cycles, it is conceivable that capacitor braking may be a suitable method.

Thus, in summarizing, when the problem arises of selecting braking for an electric drive, either the mechanical-electric or the electric method may be

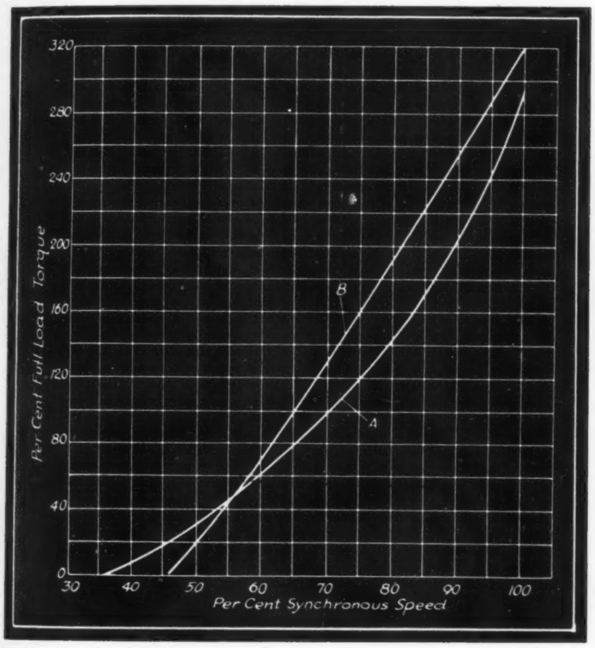


Fig. 9—Typical curves for capacitor braking for squirrel-cage motors. Curve A is for capacitor only while curve B includes a loading resistor

selected, depending on the situation. If the mechanical-electric seems indicated by the conditions of the problem, either disk or shoe type may be used. Each has the advantages of low cost, simplicity and reliability, but the disadvantages of requiring maintenance.

When straight electric braking seems best, three types are available—plugging, supplying direct current to the stator of the motor during the braking cycle, and connecting a capacitor across the stator. Generally the first is most satisfactory. All these methods have the advantage of long life under extremely severe duty cycles. Also, maintenance is a minimum for electric braking.

Although the wide range of braking methods may at first seem confusing, this variety is a definite advantage in that there usually is a method ideally suited to each particular drive and application.

Available Alternatives for Alloy Steels

VALUABLE assistance in the practically universal quest for substitutes for high alloy steels is provided by a bulletin entitled "Possible Alternates For Nickel, Chromium, and Chromium-Nickel Constructional Alloy Steel," published by the American Iron & Steel Institute. Upon government request a committee was appointed by the Institute for the purpose of studying possible alternates for chromium and nickel alloy steels. John Mitchell, of the Carnegie-Illinois Steel Corp., was chairman of the committee consisting of representatives of many of the steel and alloy producing companies.

Introduction to the booklet deals with the successive orders of the Office of Production Management beginning on September 16, 1941, through and including the priorities order of January 13, 1942. These various orders define alloy steels by their constituents and indicate the limiting proportions of alloying elements which may be processed into steel.

Along with the recommendations as to the desirable procedure for conserving alloying constituents by limiting their use in steel, methods are indicated whereby the available supply of such elements may be extended. In this connection separate consideration is given to ferromanganese, ferrosilcon, nickel, chromium, vanadium, titanium, zirconium, boron, tungsten, and molybdenum as well as special addition agents or reaction alloys. These latter elements are not mentioned specifically.

Successive sections of the book are devoted to possible alternatives for standard carburizing grades of steel, semi-through-hardening grades, and through-hardening grades. Each of these sections considers the alloy composition of the material, its reaction to heat treatment, and the attainable physical properties. These are, in turn, compared with the higher alloy steels they are intended to replace. A final chapter is devoted to standard methods for sampling and check analysis as well as standard variations from specified chemical limits of composition.

It is not the purpose of the report to present the most convenient alternatives possible for any one type of industry; rather, its purpose is to present certain types of steel which can serve the broadest possible field with the least technical complications. Use of alternative steels may make changes necessary in established methods of fabrication or heat treatment. In some cases even design changes may be necessary. For example, some types of steel are fabricated by torch cutting, bending, forming, drawing, and other operations, and the effect of these must be weighed carefully in selecting alternative steels.

Wartime Schedules Make Adequate Lighting Essential

By John J. Neidhart
Westinghouse Electric & Mfg. Co.

IMPORTANCE of lighting in engineering departments cannot be overemphasized at this time. Benefits of good lighting include increased production, greater accuracy, reduced eyestrain, and improved morale of designers and draftsmen.

The answer to the question "What constitutes good lighting for drafting rooms?" depends to some extent upon the characteristics of the room and whether horizontal or vertical boards are used. There are, however, certain general requirements which should be satisfied by any lighting installation regardless of the type of board used or the room characteristics. The average service illumination level should be in the order of 50 foot-candles or better, and the light should be free from direct or reflected glare, well-diffused, and evenly distributed over the entire working area.

Direct glare is caused by rays of light entering

Fig. 1—Above—Semidirect fluorescent luminaires provide ideal lighting for vertical drawing boards

the eye directly from a bright unshielded light source, and reflected glare is caused by reflection of light rays into the eye from specular surfaces such as glossy tracing cloth or polished T-squares, celluloid triangles, scales, etc. Glare in either of its forms is annoying and may cause discomfort or eye fatigue. Precautions should also be taken to eliminate line shadows at the working edges of triangles or T-squares. Multiple shadows from the hands or drawing instruments should also be obviated.

Aforementioned requirements may best be satisfied by a lighting installation using a large area, low brightness source of light. Prior to the advent of the fluorescent lamp, such a light source could be attained only by indirect lighting, with the ceiling acting as the light source. Indirect incandescent installations have a definite limitation, however, in that they are not satisfactory for maintained illumination levels of over 30-40 foot-candles. At higher levels the ceiling becomes too bright and the high total wattage necessary results in high operating costs and excessive amounts of heat to be dissipated.

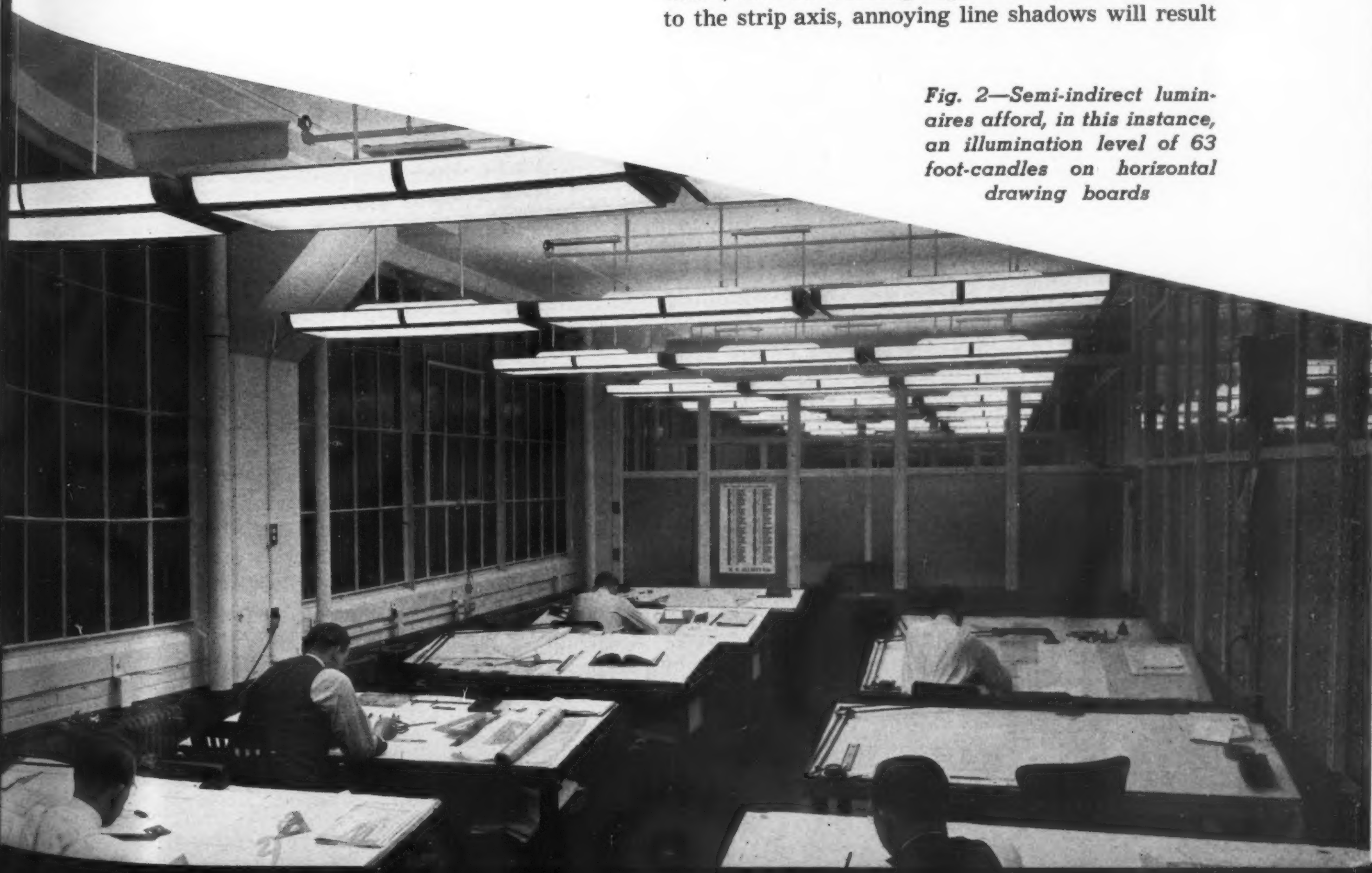
Much higher illumination levels, over 50 foot-candles, are required for the strenuous visual tasks encountered in engineering departments. The introduction of the fluorescent lamp with its high luminous efficiency, relatively low brightness and large area has recently made possible the required high levels of illumination comfortably and economically. Many different types of fluorescent luminaires are now available, and considerable care should be exercised in the selection of the type to be used. Fluorescent luminaires in which the bare, unshielded lamp is exposed to view should be avoided because the brightness of the fluorescent lamp is not so low that it may be exposed without causing glare and harsh contrasts. Properly designed semi-direct, semi-indirect, totally indirect, or direct-type fluorescent luminaires may be used if the necessary precautions are taken in the planning of the installation.

Semidirect luminaires are most applicable for lighting vertical boards since the distribution of the light from these luminaires is such that high intensities of illumination may be provided on the vertical working surfaces without harsh shadows and direct or reflected glare. The semidirect luminaire should be mounted on the ceiling in continuous strips parallel to the line of sight as shown in *Fig.* 1. The strips should be composed of 4-foot sections, mounted end-to-end, each section accommodating a 40-watt fluorescent lamp enclosed by a section of fluted diffusing glass. The continuous ceiling runner will serve both as a continuous wireway and as a housing for the ballasts. Semidirect luminaires may be obtained for two lamps per 4-foot section, but the single-lamp unit will usually be found more desirable. Closer spacing necessary for single-lamp units leads to better diffusion and a more uniform distribution of the light.

Avoids Line Shadows

When semidirect, continuous-strip luminaires are used to light horizontal drawing boards, the boards should be oriented at an angle of 45 degrees to the direction of the strips. If this precaution is not taken, and the working edge of the board is normal to the strip axis, annoying line shadows will result

Fig. 2—Semi-indirect luminaires afford, in this instance, an illumination level of 63 foot-candles on horizontal drawing boards



at the working edge of the triangle. It is also recommended that the highly polished surfaces of triangles and T-squares be lightly sandblasted.

Ideal method of lighting horizontal boards is by a semi-indirect installation such as the one shown in *Fig.* 2. The luminaire used in this installation consists of a semi-indirect body assembly for four 40-watt fluorescent lamps suspended from a two-stem hanger assembly. The luminaire body has a clear ribbed glass bottom, curved side panels of diffusing glass, decorative die-cast ends, and a centrally located ballast assembly shielded from view. The greater portion of the light from this luminaire is directed upward toward the ceiling but a considerable portion is directed downward to build up the intensity on the drawing boards. Maintained illumination levels of over 50 foot-candles may be provided by semi-indirect installations of this type.

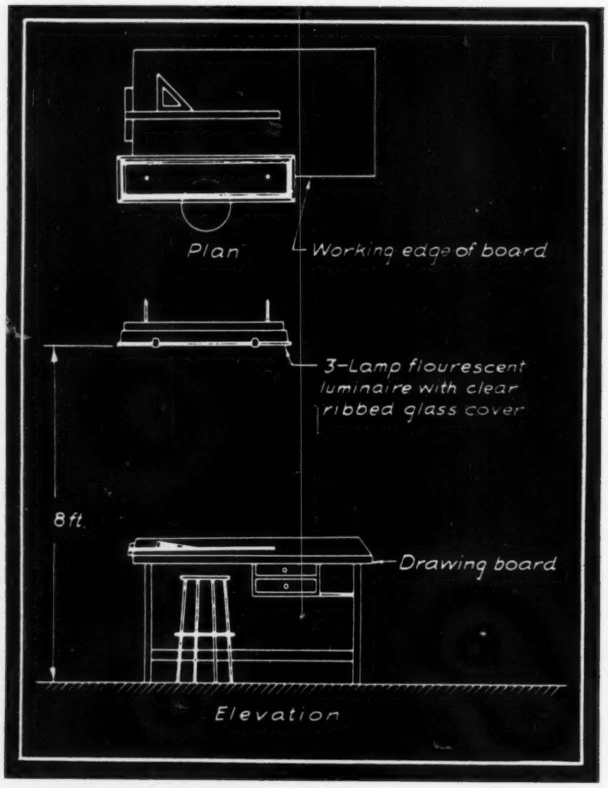


Fig. 3—Covers of clear, ribbed glass, properly oriented, make possible the use of direct-lighting fixtures

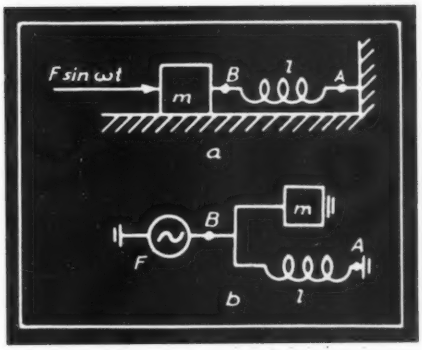
Semi-indirect luminaires of the type shown usually have an overall suspension length of approximately three feet and may be used in drafting rooms having ceiling heights of 12-15 feet. If the ceiling height is only 10-12 feet, it will be necessary to shorten the stems of the luminaire to obtain an overall suspension length of not less than 20 inches on a 10-foot ceiling or more than 33 inches on a 12-foot ceiling. The luminaire can be mounted within a foot of the ceiling if necessary on ceilings of 8-10 feet, although some utilization efficiency and diffusion will be sacrificed. Since a rather close spacing will be necessary to obtain the high levels of illumination required, it is recommended that the luminaires be mounted in continuous rows to keep the apparent number of individual luminaires at a minimum and prevent the final installation from appearing to be a forest of fixtures suspended from the ceiling. If, for example, an area of 40-45 square feet per luminaire is required, a spacing of 4½ by 10 feet is more desirable than 6 by 7 feet.

Glass Panel Provides Diffusion

To obtain a perfectly uniform distribution of the light the spacing between rows should not exceed the mounting height of the luminaire, although a reasonable degree of uniformity can be obtained with a slightly wider spacing. If the mounting height of the above example is to be 9 feet, it will be necessary to use a 5 by 9-foot spacing to obtain uniformity. The luminaires should always be mounted parallel to the working edge of the board for maximum shielding and diffusion since the ribbing in the glass bottom panel provides shielding and diffusion only in perpendicular directions.

A totally indirect fluorescent lighting installation using continuous, inverted trough-like luminaires suspended about 2½ to 3 feet below the ceiling represents the ultimate in well-diffused, high-quality illumination. Such installations are rather inefficient, however, and are not practical for maintaining illumination levels of over 30-35 foot-candles. Although incandescent lighting systems should be totally indirect for satisfactory results because the lamp is small and has a high brightness, this rule does not apply to fluorescent lighting. It cannot be denied that totally indirect light is best from the quality standpoint, but much higher levels of proper quality illumination can be obtained with semi-indirect fluorescent installations. Dollar for dollar, the slight difference in quality is no match for the great difference in quantity of light.

Ceilings of many drafting rooms in shop offices and industrial interiors are so constructed that the use of semidirect or semi-indirect commercial luminaires is impractical. In most of these cases it would be wise to install a suspended acoustic ceiling so that a semidirect or semi-indirect system may be used; but if this is not feasible, it will be necessary to install direct type industrial luminaires. Such luminaires should consist of a hood housing the ballasts, lamp holders, etc., and a porcelainlenameled reflector. It should be designed for three 40-watt lamps and should be equipped with a clear ribbed glass cover to improve diffusion and prevent direct glare. Harsh shadows and reflected glare may be prevented by mounting the luminaires directly above the working edge of the drawing boards as shown in *Fig.* 3. When mounted at a height of 8 feet above the floor, this luminaire will provide an average maintained illumination of over 50 foot-candles on the working area.



By R. C. Binder
Associate Prof. of Mech. Engrg.
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Fig. 1—Schematic diagram for simple spring-mass system depicts the elements in parallel

Applying Mobility Method to Linear Vibrations

SYSTEMS of analysis which enable the engineer to visualize what happens in a mechanical system under investigation have the prime advantage of facilitating the detection of error. In a force-vector diagram, for example, miscalculation of one of the components becomes immediately apparent when its relationship to the other vectors is examined.

Such a system is the mobility method. Starting with a mechanical system, the physical characteristics of which are known, a schematic diagram is drawn. Simple numerical calculations based upon the schematic diagram yield the desired result directly.

In applying the method to linear vibrations of mechanical elements, the same assumptions, *a, b, c,* and *d* stated in the article, "Applying Mobility Method to Shaft Vibration," February issue, Page 62, are made. Considering simple harmonic action, and using complex numbers, the relations in TABLE I apply.

Linear mobility (ease of motion) Z of an element (or a group of elements) is a complex number. The absolute value of this complex number is the amount of linear velocity produced by unit force. The angle of this complex number is the angle by which the velocity leads the force. Mobility of each of the three mechanical elements is given in TABLE II. Conventions used in constructing diagrams are the same as those used in the previous article (February, 1942, Page 148, TABLE III) with the exception that the torque vibrator is now a force vibrator and the angular velocity vibrator

IN the February issue the article, "Applying Mobility Method to Shaft Vibration," introduced this analytical method which does not require differential equations. The present article constitutes an extension of the method to linear vibrations in mechanical systems

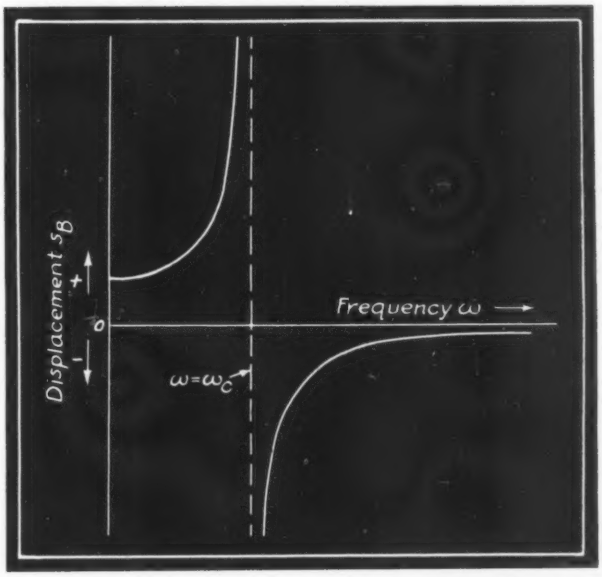


Fig. 2—When the frequency of vibration is equal to the critical, the mass displacement becomes infinite

becomes a velocity vibrator, carrying the subscripts F and V respectively.

A "force vibrator" will impress a given force amplitude on any mechanical system to which it may be connected, regardless of the mobility of that system. A "velocity vibrator" will impress a given linear velocity amplitude on any system regardless of the mobility of that system.

A "series" connection of mechanical elements is one in which the *same force* acts through all the elements, while the total linear velocity across the combination is the sum of the velocities across the individual elements. A "parallel" connection of elements results in the *same velocity* across all the elements, while the force through the combination is the sum of the forces through the individual elements.

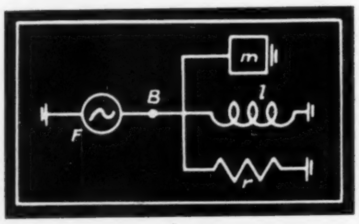


Fig. 3—A damping force applied to the system shown in Fig. 1 results in a third element in the parallel connection

Mobility of a series combination of elements is

$$Z = Z_1 + Z_2 + Z_3 +$$

where Z_1, Z_2 and Z_3 are the individual mobilities.

Mobility of a parallel combination of elements is

$$Z = \frac{1}{\frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3} +}$$

The mobility method involves drawing the schematic diagram of the mechanical system and applying the above simple relations.

Some fundamental concepts can be illustrated by reference to simple systems. As one case, the spring-mass system without damping shown in *Fig.* 1*a* may be considered. An oscillating force $F \sin \omega t$ is applied to the mass. The schematic diagram, *Fig.* 1*b*, shows the elements in parallel because one terminal of each element is the fixed point and their other terminals are fastened together. The mobility of point B is

$$Z_B = \frac{1}{\frac{1}{j\omega l} - \frac{1}{\frac{j}{\omega m}}} = \frac{j}{\frac{1}{\omega l} - \omega m} \quad \text{.............. (1)}$$

TABLE I

Properties of Mechanical Elements

Property	Instantaneous Value	Amplitude
Linear displacement	$s_i = s\epsilon^{j\omega t}$	s
Linear velocity	$v_i = v\epsilon^{j\omega t}$	$v = j\omega s$
Linear acceleration	$a_i = a\epsilon^{j\omega t}$	$a = j\omega v = -\omega^2 s$
Force	$F_i = F\epsilon^{j\omega t}$	F

Since a vibrating force of amplitude F is applied at point B, the velocity amplitude at B is $v = ZF$. The displacement amplitude s_B at point B is the displacement of the mass.

$$s_B = \frac{v}{j\omega} = \frac{F}{\omega}\left[\frac{1}{\frac{1}{\omega l} - \omega m}\right] \quad \text{................ (2)}$$

A diagrammatic plot of displacement amplitude for a variation of frequency is shown in *Fig.* 2. Equation 2 shows that the mass displacement becomes infinite when the denominator of S_B is zero. Let $\omega = \omega_c$ at this resonant condition. Then $1/\omega_c l = \omega_c m$

$$\omega_c = \sqrt{\frac{1}{lm}} \textit{ radians per second}$$

$$f_c = \frac{1}{2\pi}\sqrt{\frac{1}{lm}} \textit{ cycles per second} \quad \text{............. (3)}$$

This illustrates a useful feature. The mobility of any vibrating mass and the system to which it is connected is infinite at a natural frequency. Equation 2 and *Fig.* 2 show that when $\omega < \omega_c$ the displacement amplitude is positive. When $\omega > \omega_c$ the displacement amplitude is negative. The mobility changes sign when passing through infinity. This fact is sometimes useful in calculating the natural

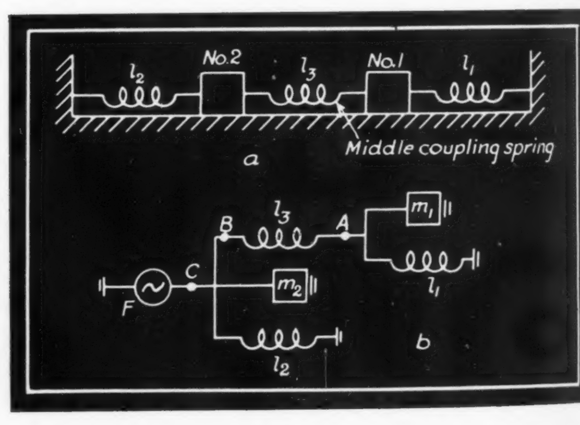


Fig. 4—More complicated systems of springs and masses are easily solvable from the schematic diagram

frequencies for complicated systems.

Assuming the mass weighs 20 pounds, and the spring is such that a force of 1 pound would give a spring deflection of .005-inch, the natural frequency is

$$f_c = \frac{1}{2\pi}\sqrt{\frac{386}{20(.005)}}$$

$$f_c = 9.9 \textit{ cycles per second}$$

Considering the case in which the mass in *Fig.* 1*a* rides on an oil film, the viscous drag of the lubricant gives rise to a resisting force. It is assumed that this resisting force equals some constant C times the linear velocity. The responsiveness r of the re-

sistor is the reciprocal of C. The schematic diagram for this case is shown in *Fig.* 3. Mobility at point B is

$$Z_B = \frac{1}{\frac{1}{j\omega l} - \frac{\omega m}{j} + \frac{1}{r}} \qquad (4)$$

Since the denominator in Equation 4 will never be zero, the displacement amplitude will always be finite. The amplitude may be large in the region of the natural frequency.

Many important practical cases involve the vibrations of more than one mass and one spring. To illustrate the general method of attack for these

TABLE II

Mobility of Elements

Spring	$Z = j\omega l$
Mass	$Z = -\frac{j}{\omega m}$
Resistor	

more complicated problems, the system shown in *Fig.* 4*a* with two masses, three springs, and no damping will be considered, assuming that an oscillating force $F \sin \omega t$ acts on mass No. 2.

Referring to the schematic diagram in *Fig.* 4*b*, the mobilities at the various points can be calculated by using the relations for series and parallel connections.

$$Z_A = \frac{1}{\frac{1}{j\omega l} - \frac{\omega m_1}{j}}$$

$$Z_B = j\omega l_3 + \frac{1}{\frac{1}{j\omega l_1} - \frac{\omega m_1}{j}} \qquad (5)$$

Continuing through the system, the mobility at point C becomes

$$Z_C = \frac{j\omega[l_3 l_2(1-\omega^2 l_1 m_1) + l_1 l_2]}{(1-\omega^2 m_2 l_2)\,(l_3 - \omega^2 l_1 l_3 m_1 + l_1) + l_2 - \omega^2 l_1 l_2 m_1} \qquad (6)$$

In order to simplify illustration, the case may be considered in which the masses are identical and each spring has the same compliance. Then $l_1 = l_2 = l_3 = l$ and $m_1 = m_2 = m$, and Equation 6 becomes

$$Z_C = \frac{j\omega l[2-\omega^2 lm]}{[1-\omega^2 ml][3-\omega^2 lm]} \qquad (7)$$

Natural frequencies are determined by making Z_C approach infinity, or simply setting the denominator of Equation 8 equal to zero. The two natural frequencies f_1 and f_2 are then

$$f_1 = \frac{1}{2\pi}\sqrt{\frac{3}{lm}} \text{ cycles per second}$$

$$f_2 = \frac{1}{2\pi}\sqrt{\frac{1}{lm}} \text{ cycles per second} \qquad (8)$$

If each mass weighs 10 pounds, and the compliance of each spring is .01-inch per pound, $f_1 = 17.1$ cycles per second and $f_2 = 9.9$ cycles per second as the natural frequencies of this system under the conditions stated in the foregoing.

Behavior of the system can be studied further by calculating the ratios of the displacement amplitudes of the two masses. Let s_1 be the displacement amplitude of mass No. 1, and let s_2 be the displacement amplitude of mass No. 2 in the system of *Fig.* 4*a*.

Referring to *Fig.* 4*b*, F is the force amplitude at

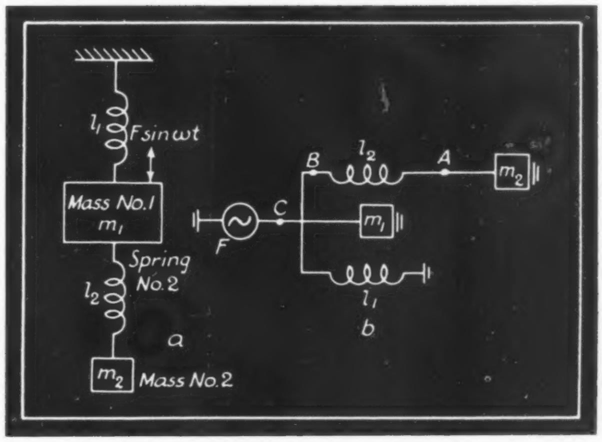


Fig. 5—Proper spring selection makes possible the balancing of large masses by means of small compensating masses of predetermined frequency

point C. The velocity of point C is thus $v_c = Z_c F$; v_c is the velocity of mass No. 2 (parallel connection). Then

$$s_2 = \frac{Z_C F}{j\omega} \qquad (9)$$

The next step is to calculate s_1. Velocity of point B equals velocity of point C. Then $v_B = v_c$. The force through point B is

$$F_B = \frac{v_B}{Z_B} = \frac{Z_C F}{Z_B} = F_A$$

The velocity of point A is

$$v_A = Z_A F_A = \frac{Z_A Z_C F}{Z_B}$$

Therefore

$$s_1 = \frac{Z_A Z_C F}{j\omega Z_B} \qquad (10)$$

From Equations 5, 9 and 10

$$\frac{s_1}{s_2} = \frac{Z_A}{Z_B} = \frac{1}{2-\omega^2 ml} \qquad (11)$$

Equation 11 gives the ratio of the displacement amplitudes for any frequency ω. If the two natural

frequencies are inserted in Equation 11 two values of the ratio s_1/s_2 are obtained:

$$\frac{s_1}{s_2} = +1 \qquad \frac{s_1}{s_2} = -1$$

The condition that $s_1/s_2 = +1$ means that the two masses move in the same direction through the same distance. The middle coupling spring, *Fig. 4a,* is not stretched or compressed in this process. The condition that $s_1/s_2 = -1$ means that the two masses move through the same distance but in opposition to each other; the motion is wholly symmetrical with respect to the midpoint of the coupling spring. Therefore, there are two "natural modes of motion," each with its corresponding natural frequency.

Causes Undesirable Vibrations

A machine or machine part on which a steady alternating force of a certain frequency is acting may be subject to obnoxious vibrations, especially when it is close to resonance. A practical method of eliminating such undesirable vibrations lies in the application of a suitable vibration absorber.

In *Fig. 5a* is a large mass m_1, as a machine part, with an alternating force $F \sin \omega t$ acting on it. The vibration absorber consists of a comparatively small mass m_2 and a spring of compliance l_2 connected to the large mass. The displacement of mass No. 1 can be made equal to zero by a suitable selection of m_2 and l_2. The schematic diagram is shown in *Fig. 5b.*

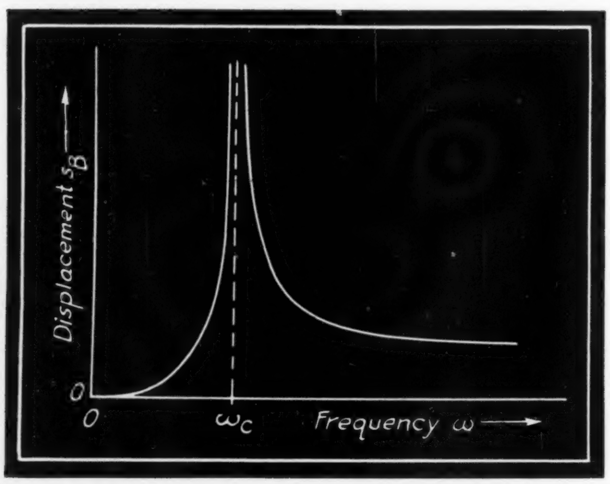


Fig. 6—Resonance diagram indicates the manner in which displacement approaches infinity as the frequency approaches the critical

The displacement amplitude of mass No. 1 is

$$s_1 = \frac{v_C}{j\omega} = \frac{Z_C F}{j\omega}$$

Since the velocity of point B equals the velocity of point C, the force F_B acting through spring No. 2 is calculated as follows:

$$v_B = v_C = Z_B F_B = Z_C F$$

$$F_B = \frac{Z_C F}{Z_B}$$

The force acting through spring No. 2 acts on mass No. 2. Then

$$s_2 = \frac{v_A}{j\omega} = \frac{Z_A Z_C F}{j\omega Z_B}$$

Ratio s_1/s_2 then becomes $s_1/s_2 = Z_B/Z_A$ and

$$s_1 = -\omega m_2 s_2 \left[\omega l_2 - \frac{1}{\omega m_2} \right] \quad \dots\dots\dots (12)$$

Equation 12 shows some important and practical features. While the small mass No. 2 may vibrate with an amplitude s_2, the amplitude s_1 of mass No. 1 equals zero when $\omega l_2 - 1/\omega m_2 = 0$, or

$$l_2 m_2 = \frac{1}{\omega_2} \quad \dots\dots\dots (13)$$

At a certain frequency, mass No. 1 does not vibrate if l_2 and m_2 satisfy Equation 13.

Practical Examples Considered

Considering the case of a mass weighing 1000 pounds acted upon by a vibrating force having a frequency of 20 cycles per second, if this is a resonance condition the vibration may be undesirable. The vibration can be absorbed by a smaller mass-spring system in which l_2 and m_2 satisfy

$$l_2 m_2 = \frac{1}{(2\pi 20)^2}$$

If the smaller mass weighs one pound, a spring of compliance of .0244-inch per pound is required.

Previous examples involved an impressed force amplitude F *independent* of the frequency ω. Another technically important case is that in which F is proportional to ω^2. Cases of this kind are encountered in studies of the critical speeds of rotating machinery.

As an illustration, a simple beam on two supports and carrying an unbalanced motor in the middle will be considered. While operating, the motor axle experiences a rotating centrifugal force $m\omega^2 d$, where m is the mass of the unbalance and d its distance from the center of the shaft. This rotating force can be resolved into a horizontal component $m\omega^2 d \cos \omega t$ and a vertical component $m\omega^2 d \sin \omega t$. Assuming that the beam is stiff in the horizontal direction but flexible in the vertical, the system is simply a mass m (the motor) connected to a spring (the beam) free to vibrate vertically.

Disturbing force amplitude is $m\omega^2 d$, which is de-

(*Concluded on Page* 134)

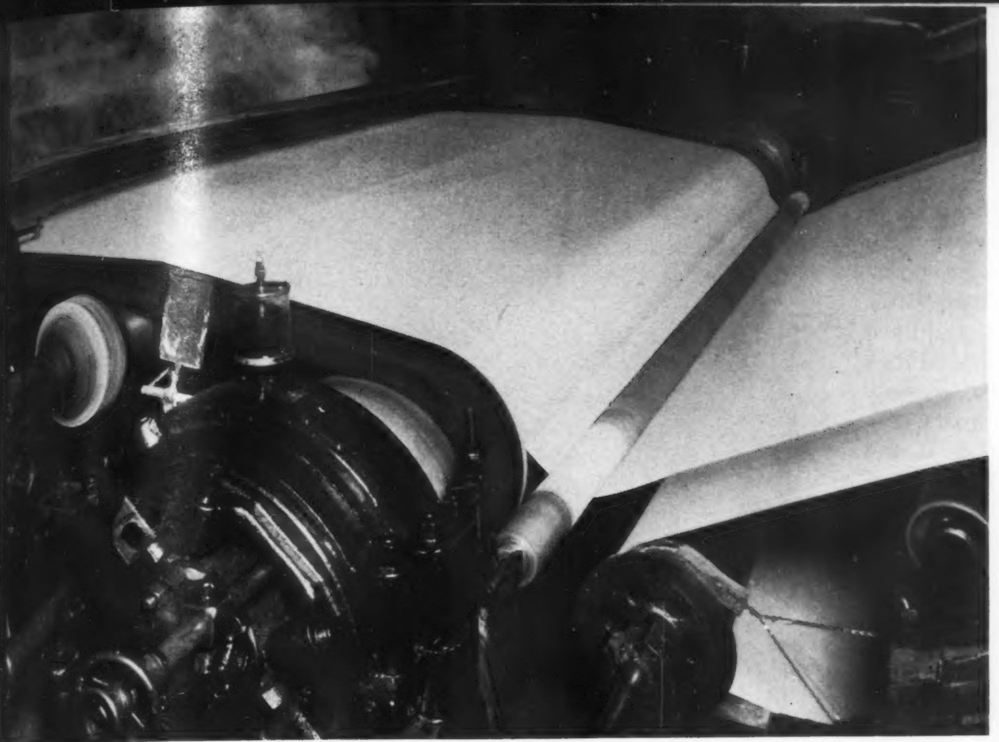


Fig. 1—Severe operating conditions involving corrosive action, high tension, wear and flexing over rolls are withstood by fourdrinier screens on wet end of paper machines

Basic Considerations in Selecting Screens

By John W. Greve

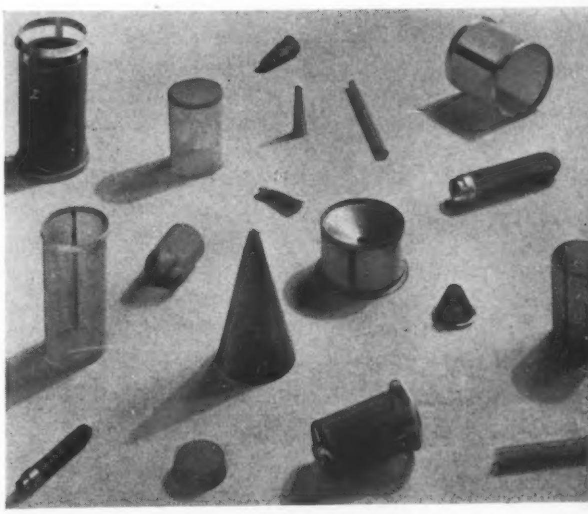


Fig. 2—Assortment of strainers used for aircraft in the fuel tank, in the line between tank and carburetor, in the carburetor, and in air intake

WHETHER wire cloth, perforated metal or other types, screens are called upon to perform exacting tasks for innumerable machines. In aircraft, tanks and other motor-driven military equipment, screens protect vital fuel and lubricant supply. Powder for shells, ingredients for making steel, materials for the preparation of aluminum involve screen applications and are typical of the wide utilization in equipment and processes.

Fundamental considerations that are helpful in applying screens will be presented in this article. Unfortunately, however, there are no rigid criteria that can be applied for the final selection. Experience and laboratory tests are often needed. Resistance to corrosion, abrasion, vibration or other destructive forces, and ability to run over rolls at high speeds as in *Fig.* 1, are requirements for many applications. In considering a particular case the type of screen, metal, mesh and shape of opening often becomes an involved problem.

General screening processes fall into four groups: Straining for removing sizable particles from liquids, filtering for separating all solids from liquids, sizing for grading materials, and washing as in the cleaning of materials or recovery of products. Other applications not classified as screening such as ventilators, guards, and products will not be treated.

To meet requirements of most commercial applications, over 8000 specifications of the wire cloth type of screen material are available. When those for other types such as perforated metal, expanded metal, electroformed screens, bar screens and link screens are added, an impressive selection presents itself to the designer.

Size of opening is probably the

primary consideration in applying screens, this being governed by the necessity of passing the maximum size of material permissible. For wire cloth the opening is determined from the diameter of the wire strands and the mesh or number of strands per inch. Frequently there is a difference in mesh specification if the fines are the salvage material or if they are the waste product. If a high efficiency is desired in the oversize, a slightly larger opening in the screen cloth is used than if the reverse conditions were true. Also, for instance in vibrating screens, the angle of operation will allow the use of a larger opening because the inclination of the surface reduces the clear opening. The degree to which this is effective varies with the pitch, action of the screen unit and the nature of the material. These considerations do not apply, however, to pressure filtering which will be discussed later in the article.

In TABLE I are shown normal or market grades of square-mesh wire cloth. Square mesh indicates that the size of openings, or in other words the wire count, is the same in both directions. This is in contrast to oblong mesh and other weaves of cloth. Being stock grades the wires listed should be selected wherever possible. Weights of cloth for steel, copper, brass and monel are given. For special alloys not shown in the table, TABLE II shows weights of common alloys in percentage of plain steel from which the weights of other screens may be calculated from the values for plain steel listed in TABLE I.

Fig. 4—Drum screen has sectional elements giving support to the screens and facilitating maintenance. Screens are backed by heavy wide-mesh wire cloth

TABLE I

Market Grades of Wire Cloth

Mesh (count per inch)	Diameter of Wire (inches)	Width of Opening (inches)	Open Area (per cent)	Weight per square foot (pounds): Plain steel	Pure copper	80/20 Brass	Monel metal
2.....	.063	.437	76.4	.512	.580	.566	.574
3.....	.054	.279	70.1	.567	.643	.627	.636
4.....	.047	.203	65.9	.576	.653	.637	.646
5.....	.041	.159	63.2	.549	.622	.607	.616
6.....	.035	.132	62.7	.481	.545	.532	.540
8.....	.028	.097	60.2	.411	.466	.454	.461
10.....	.025	.075	56.3	.412	.467	.455	.462
11.....	.023	.068	56.0	.384	.435	.424	.431
14	.020	.051	51.0	.372	.422	.411	.417
16.....	.018	.045	50.7	.345	.391	.381	.387
18.....	.017	.039	48.3	.348	.394	.385	.390
20	.016	.034	46.2	.344	.390	.380	.386
24.....	.014	.028	44.2	.318	.360	.351	.357
30.....	.013	.020	37.1	.348	.394	.385	.390
40.....	.010	.015	36.0	.276	.313	.305	.310
50.....	.009	.011	30.3	.284	.322	.314	.319
60.....	.0075	.009	30.5	.237	.269	.262	.266
65.....	.0065	.009	33.5	.191	.216	.211	.214
80.....	.0055	.007	31.4	.169	.192	.187	.190
90.....	.005	.006	30.1	.158	.179	.175	.177
100.....	.0045	.006	30.3	.142	.161	.157	.159

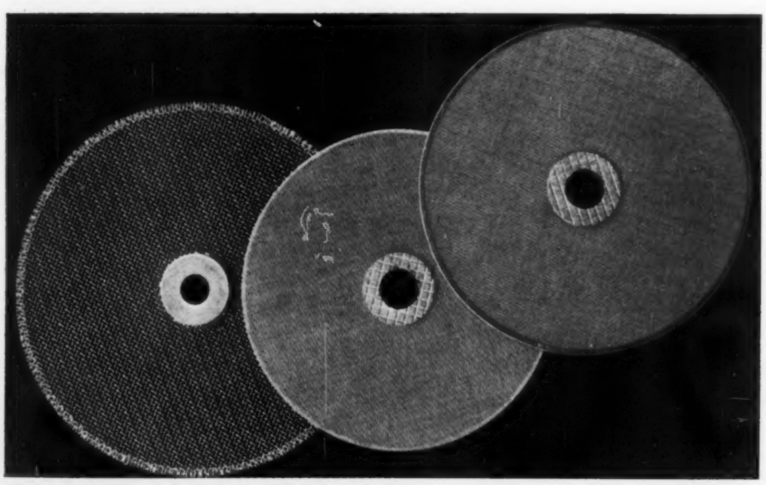


Fig. 3—Disk strainers having soldered gaskets and self-edge for strength, seal, and prevention of raveling

Weaves other than square mesh are applied to advantage in special equipment. If fibrous materials, for instance, are being screened, oblong mesh is usually employed. For such weaves the mesh is expressed by the count in both directions, lengthwise count being first, i.e., 20 × 40 mesh means twenty openings per linear inch lengthwise and forty across the cloth. Principal weaves are:

1. Plain: For large majority of applications. It is simplest, most inexpensive and has a high percentage of open area with consequent high output.
2. Twill: For strength and wearing qualities. It is firm in texture, each wire being locked by cross wires, preventing uneven openings from severe service. Used to advantage where formed or shaped screen is needed.
3. Plain Dutch: For filters where filtering and strength properties are essential. Often it is used instead of backing a plain weave with a stronger, coarser mesh. This weave possesses

Table II

Weights of Metals Compared with Plain Steel

Metal	Relative Weight (per cent)
Pure iron	100.22
High brass (70/30)	108.73
Commercial bronze (90/10)	112.25
Phosphor bronze (Grade A)	113.09
Everdur and olympic bronze	108.89
Pure nickel	112.84
Stainless steel (18/8)	100.98
Nichrome I	104.45
Nichrome V	106.54
Aluminum (X-56-S)	34.17

high capacity.

4. Dutch Twill: For filtering. Combines the capacity of Dutch weave with the pliability of twill for forming.

5. Oblong Slot: Used for high-capacity screening. Freedom from clogging and blinding makes it useful for fibrous, wet or corrosive materials.

Other weaves, though not as common, are adaptable to special problems. They include: Double weave and cabled weave, using variations of multiple strands for flexibility; square wire weave where straight-sided mesh and sharp surface are desirable; rolled weave where (aside from setting the mesh) a flat surface is needed for ease in cleaning or for backing another screen; link weaves where screen acts as a belt in conveyors.

Any ductile metal or alloy may be woven into wire cloth. Selection of the metal depends both on the strength required and the resistance to attack by corrosion, wear, etc. Principal metals used and their properties are:

1. Aluminum: Used where light weight and resistance to attack by nitric or sulphuric acids are required at ordinary temperatures.

2. Brass: Used where higher strength and hardness are required than obtainable with copper. It is not resistant to some acids and ammonia.

3. Commercial bronze: Used where more strength and flexibility are required than obtainable with copper.

4. Copper: Used only where chemical and electrical conditions require. It is resistant to dilute sulphuric and hydrochloric acids but is attacked by ammonia and nitric and other oxidizing acids.

5. Everdur: Developed for structural and engineering uses, it has the strength and fabricating qualitites of steel combined with resistance to rust. Corrosion resistance is equal to copper and it can be satisfactorily fusion welded.

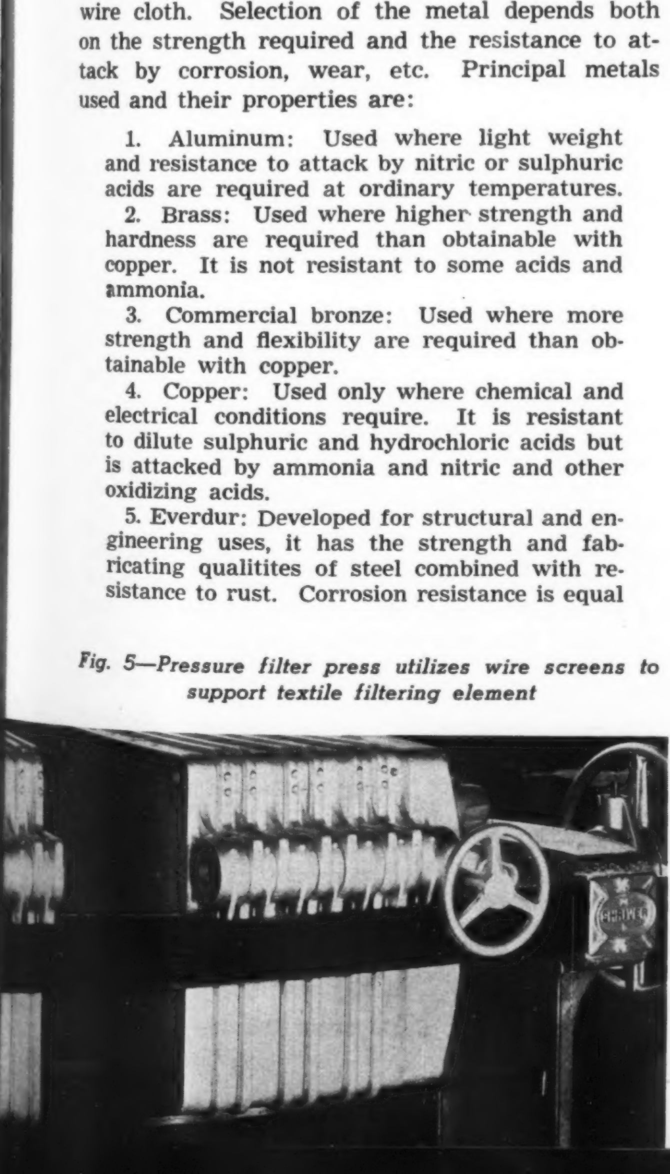
6. Iron and steel: Used where economy and strength are necessary. Acids and alkalies limit and restrict their application. Iron is the more resistant to alkaline solutions.

7. Monel: Used largely in the chemical and food industries. It combines strength with resistance to abrasion, corrosion, impact, fatigue and high temperatures.

8. Nickel: Used in salt and alkaline solutions, steam, food and dairy production of low acidity. Has high resistance to corrosion and freedom from contamination. It is not highly resistant to nitric, sulphuric, chromic acids.

9. Phosphor bronze: Used where superior qualitites than obtainable with commercial bronze are necessary.

Fig. 5—Pressure filter press utilizes wire screens to support textile filtering element



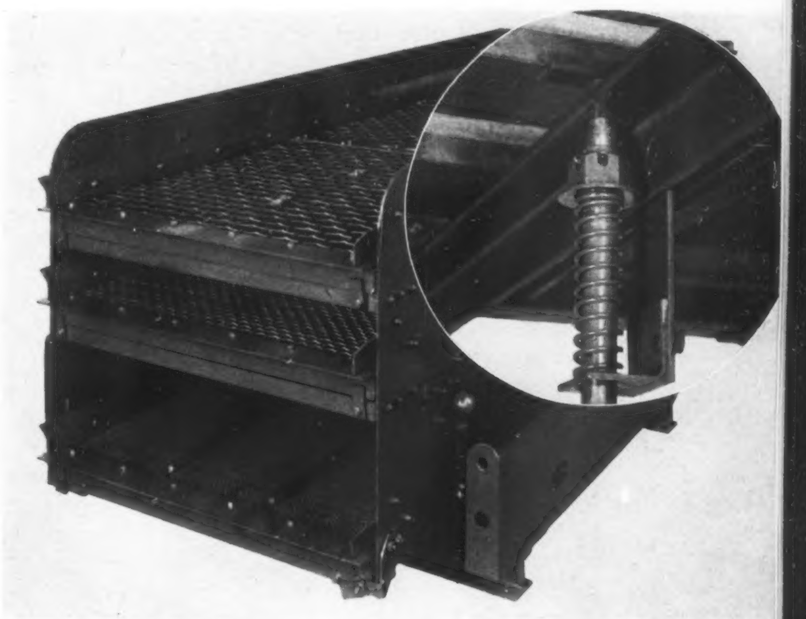


Fig. 6—Three-deck vibrating screen separates four sizes of material in one operation. Device shown in insert is used to clear fine mesh screen, vibrations of which cause hammer blows

10. Stainless steel: Used where ultimate in corrosion resistance and high ductility are required.

Perforated or stamped screens, although more costly through uneconomical use of material and type of equipment needed in manufacture, have wide use especially for drum screens and where unsupported sections must retain a certain amount of rigidity or conform to accurate shape. Because percentage of open area is less than for wire screen, perforated screens necessarily do not have as great a capacity. With respect to sizing, however, extremely accurate results can be obtained without danger of variations through abuse. Holes may be tapered for self-cleaning, minimizing dangers of clogging. In sanitary equipment this type of screen is easily cleaned.

Straıners, when used to prevent foreign par-

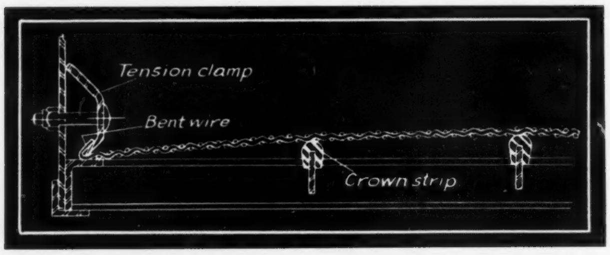


Fig. 7—Transverse vertical section of a screen mounting for a vibrating screen. Wire is bent to engage tension clamp. Crown strip has rubber nose

ticles from causing damage in a fuel or lubrication supply line, require sufficient screen area (to prevent possible blinding) and corrosion resistant metal in addition to proper size of opening. Sufficient strength in the strainer as well as adequate support are also necessary. Increased area of openings may be effected by funnel-shaped filters, other extended shapes, or enlarging the cross section.

If possible, strainers should be applied so that they will be self-cleaning. In other words, flow should be against gravity with an ample-volume sump that will not become agitated. In *Fig.* 2 is shown a group of aircraft screens that are typical of this type of application. They are aluminum, monel, stainless, brass or copper strainers. For processes where gravity straining is necessary, ample area in the screen must be provided or provisions for cleaning or agitating become necessary to prevent blinding.

Usually small strainers are gasketed and soldered for strength and ease of assembly. Two types of gasketing are shown in *Fig.* 3. When forming is necessary, twilled weaves are selected because of their ability to deform without undue change in size of mesh openings. Forming, however, preferably should be a minimum. Cloth in large strainers, *Fig.* 4, should be backed by a course supporting cloth to prevent bulging, resulting in clogging or otherwise erratic operation.

When a considerable quantity of fluid is passed through a screen the problem of pressure drop becomes important. In view of the fact that the effective orifice coefficient of wire cloth may be less than 50 per cent, it is desirable that the total net open area of the strainer be at least twice that of the pipe in which it is installed.

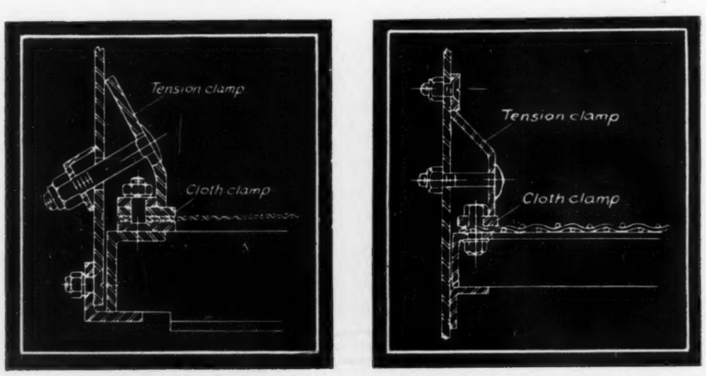


Fig. 8—Two methods of clamping screens where mounting strips are needed. Design at right shows screen mounted in a removable panel

Pressure filtering of fluids containing suspended solids involves special considerations in that the screens become merely supports for a cake which forms on them. Selection of the cloth is influenced by the pressure, temperature and the corrosive action of the materials handled. Some plate-type filters utilize wire cloth for backing textiles as in *Fig.* 5. Filter screens are usually gasketed in a sewed frame of canvas, in soldered or brazed metal, or in vulcanized rubber. In addition to sealing the filter against leaks, gaskets prevent "ragging out" of the wire cloth and facilitate handling. Determination of proper cloth to utilize is a subject for laboratory investigation and recommendation of the cloth manufacturers.

Lately there have been instances where wire cloth has been used to replace alundum, carborundum and porous metal filters. It has the advantages of being light in weight, not fragile, and readily removed for cleaning. In some instances filters utilize two concentric cylinders of wire cloth with glass wool, shredded metal or other fibrous material filling the space between the cylinders.

TABLE III

Typical Capacities of Vibrating Screens

Square Opening (inches)	Capacity (tons per sq. ft. per hour)
⅛	¾
¼	1¼
½	2
¾	3
1	3½
1¼	4
2	5

Vibrating screens, as in *Fig.* 6, are universally used for grading, washing or drying. There are two general types of such equipment, horizontal and inclined, the latter being 25 to 35 per cent more efficient. Flow of material through horizontal screens is induced solely by the vibrations of the unit; that through inclined ones is assisted by gravity. In a counter-flow method, however, the vibrator opposes the direction of flow. In this type blinding is more critical, making the depth of material on the screen as well as the mesh and wire gage of the screen itself more important. Because inclined screens have a tendency to roll particles, they will screen more odd shapes.

Screens for vibrating units are usually designed to carry an average depth of material of four times the mesh opening. Typical capacities are shown in TABLE III. So many variables enter into a determination of capacities, however, such as density of material, nature and character of particles and percentage of material that passes through the screen that this table is presented only to show

relative capacities of different size screens.

Amplitude of vibration is important for proper operation. Too slow a rate results in decreased capacity and too fast a rate passes some material that would otherwise be screened. For screening gravel, for instance an amplitude of vibration of ¼-inch is typical for ¼-inch screen openings. Smaller or larger openings require proportionately smaller or larger amplitudes for efficient operation. As meshes exceed 300 the extreme fineness of particles may result in their being "air borne" with the result that they will not pass through the screen. Reduced inclines and smaller amplitudes of vibration are then indicated. Fine screening of

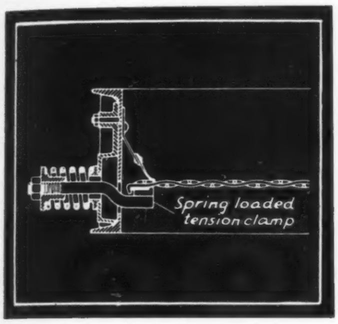


Fig. 9 — Spring-tensioned clamp for accurately controlling tension on screen even though slight stretching occurs

wet materials requires vibration to break up capillary attraction in addition to utilizing motion for passing the material.

If moisture content of the material is high, slotted openings in the screen would probably reduce blinding, provided material is fairly uniform in size and does not contain slivery particles which would be objectionable in the finished produc passing through the screen. If the use of square mesh cloth is necessary, light grade of wire should be considered.

Following is a brief tabulation of typical specifications for sizing screens.

1. Heavy abrasive materials: Screen openings 4 inches and over of cast manganese or high-carbon steel plates.
2. Coarse sizing nonabrasive friable material: Screen openings 2 inches and over of wire cloth in flat top weave of either oil-tempered or spring steel.
3. Heavy or abrasive materials, wet or dry: Screen openings ⅛-inch and over of oil-tempered wire.
4. Damp nonfingery shaped material: Screens of a relatively light wire with long-slotted openings. Relative length of slot depends on weight of overload and possibilities of openings being spread by wedging action.
5. Fine mesh sizing, dry or wet: Screen down to 50 mesh of plain steel wire provided no chemical action would take place, otherwise an alloy wire. Below 50 mesh, stainless steel or monel is preferable for mechanical reasons if chemical considerations permit.

Many fine powders, particularly those in the starch family and some damp materials such as fine fire clay, stone dust, etc., handle better on silk bolting cloth than on steel. This likewise is true in a number of cases where serious blinding occurs with near-size particles. Silk distorts slightly, permitting the particles to work through. Further, silk is used frequently on abrasives where, because of the difference in coefficient of friction, better service than that obtainable with metal cloth is obtained for garnet, emery, etc. Silk will not stand up, however, under heat. Where high temperatures are involved steel cloth is satisfactory as high as 700 degrees Fahr. Brass or bronze is not useful in the range of 250 to 300.

Mountings for screens in vibrating units are more important than for others. Considerable research has been done by manufacturers of cloth to develop effective mountings that will properly support the cloth and produce necessary tension and crown. The cloth must be stretched taut or drum tight, the amount depending on the load and restricted by nature of the screen. Insufficient tension, resulting in whipping, is troublesome. In addition to materially shortening the life of the

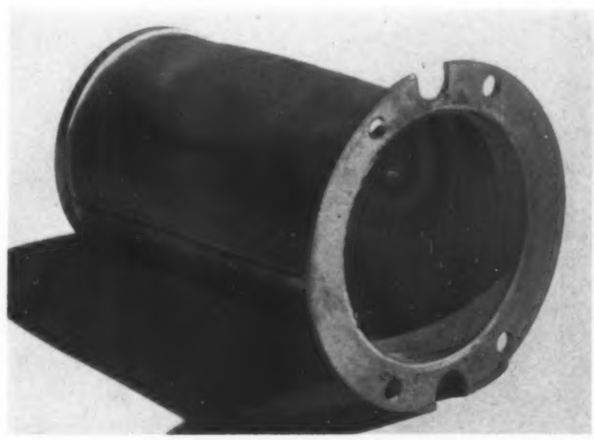


Fig. 10—Fabricated strainer for which screen was produced by electrolytic method

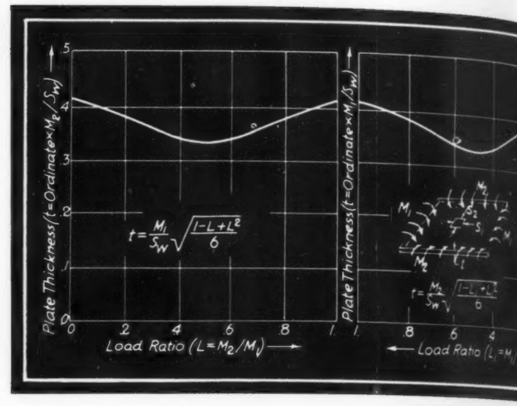
screen through fatigue, flexing causes near-size particles to blind the openings.

When the cloth has sufficient strength, it is usually bent hook-shape on the edge and the tensioning clamp bars engage this hook. If the cloth does not have the strength, strips are attached along the top and bottom of the edges and bolted through. These strips then are attached to the clamping devices. Typical methods of tensioning are shown in *Figs.* 7, 8 and 9.

Crown affects both operation and screen life. It is usually obtained from strips spaced longitudinally under the screen and supported from the cross members of the frame as shown in *Fig.* 7. Sometimes crown strips are supported from above by adjustable links. Where rubber can be used without affecting the screen or material and without being affected by them, the crown strips have rubber nose pieces to cushion the screen and protect it from abrasion. Screen life is greatly in-

(Concluded on Page 128)

Fig. 1—Required thickness of plate for load ratio



Charts Aid in Determining Plate Thickness

By Joseph Marin

Pennsylvania State College

STRESS analysis of thin plates subjected to lateral loads, found in many machines and structures, shows they are subjected to a combined state of stress. As in the previous articles of this series[1], the combined stress effect will be considered and the thickness of plates determined by taking into account the influence of stresses in more than one direction. For this purpose the distortion energy theory will be used. In addition, design charts will be presented for the convenience of the designer. This makes readily possible the selection of thickness of plate required for a given loading.

Thin plates have received the attention of many investigators and several books have been written on this subject[2]. The equations for the stresses used in the present discussion are based on these investigations. The stresses are expressed in terms of the dimensions and of the loads acting on the plate.

In applying the distortion energy theory, the limitations of the design charts discussed later should be mentioned. Plates laterally loaded will be considered, because other types of loading introduce new problems such as failure by buckling due to compression in the plane of the plate. Examples of plates in which the deflections and thickness are small also will be treated. For this reason, the design charts show maximum thickness to radius ratios of one-tenth. By considering thin plates, only the bending stresses need be analyzed; shear stresses may be neglected since they are small. The number of examples treated is limited since there are too many shapes of plates and types of loading to include charts for all. Thickness of plates will be based on strength only.

1. Rectangular Plate Subjected to Bending Moments Along the Edges: For the plate shown in *Fig.* 1, M_1 and M_2 are the moments per unit length. Then the bending stresses on the face of the plate and in the plane of these moments are

$$S_1=\pm\frac{6\,M_1}{t^2}\ ,\quad S_2=\pm\frac{6\,M_2}{t^2}\ \ldots\ldots\ldots\ldots\ldots\ldots(a)$$

where t is the thickness of the plate. The distortion energy for an element subjected to stresses S_1 and S_2 is

$$V=k(S_1^2-S_1S_2+S_2^2)\ \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

where k is $(1+m)/3E$, m is Poisson's ratio and E is the modulus of elasticity.

Since the stresses are the same for all points on the surfaces of the plate, the distortion energy will be the same for all points. From Equations a and 1 its value is

$$V=k\left(\frac{6}{t^2}\right)\left(M_1^2-M_1M_2+M_2^2\right)\ \ldots\ldots\ldots\ldots(b)$$

The allowable value of V is

$$V_w=kS_w^2\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where S_w is the working stress.

[1] "Designing Shafting for Static or Fatigue Loads," August, 1941; "Safe Speeds for Flywheels," January, 1942; "Designing Short Beams," February, 1942.

[2] The most recent book on plates is *Theory of Plates and Shells*—S. Timoshenko, McGraw-Hill Book Co., 1940.

Equating the value of the distortion energies from Equations b and 2, the required thickness of plate is

$$t=\left(\frac{M_1}{S_w}\right)\sqrt{\left(\frac{1-L+L^2}{6}\right)} \quad \text{(3a)}$$

or

$$t=\left(\frac{M_2}{S_w}\right)\sqrt{\left(\frac{1-L_1+L_1^2}{6}\right)} \quad \text{(3b)}$$

where $L = M_2/M_1$ and $L_1 = M_1/M_2$.

By selecting values of L and L_1 from 0 to 1, all

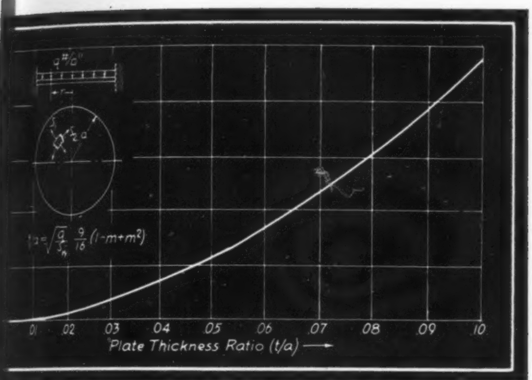


Fig. 2 — Left — Thickness ratio for circular plates using Poisson's ratio of .3, fixed at edge and uniformly loaded

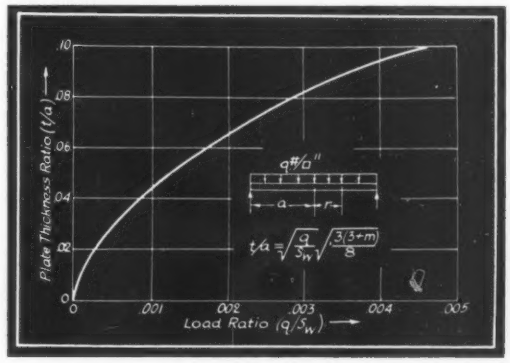


Fig. 3 — Right — Thickness ratio for simply supported circular disk, uniformly loaded

possible ratios of the moments are considered. Plots of Equation 3 are shown in *Fig.* 1 from which the plate thickness can be obtained for a given load ratio.

Circular plates are employed in many machines as diaphragms, pistons, cylinder heads and boiler heads. An approximation of some cases of circular plates is given in the following examples.

2. Circular Plate Fixed At Edge and Uniformly Loaded: A plate fixed at the edges and uniformly loaded is shown in *Fig.* 2. Bending stresses at a point a distance r from the center are shown by the following:

$$S_1=\frac{3a^2q}{8t^2}\left[(3+m)\frac{r^2}{a^2}-(1+m)\right]=A(k_1x^2-1) \quad \text{(c)}$$

$$S_2=\left(\frac{3a^2q}{8t^2}\right)\left[(3m+1)\frac{r^2}{a^2}-(1+m)\right]=A(k_2x^2-1) \quad \text{(d)}$$

where

$$A=\frac{3a^2q}{8t^2}(1+m)$$

$$k_1=\frac{3+m}{1+m},\quad k_2=\frac{3m+1}{1+m}$$

$x = r/a$, q = the load per unit area and a = the radius of the plate.

Placing values of the stresses from Equations c and d in Equation 1, the distortion energy for an element at a distance r is

$$V=kA^2[x^4(k_1^2-k_1k_2+k_2^2)-k_1k_2x^2+1] \quad \text{(e)}$$

The critical element will be, by calculus, the one for which V is a maximum, or for $dV/dx = 0$. From Equation e, this is for values of

$$x=0, \text{ or } x=\sqrt{\frac{k_1+k_2}{2(k_1^2-k_1k_2+k_2^2)}} \quad \text{(f)}$$

Placing these values of x in Equation e the values of V are, respectively

Fig. 4—Below—Variations in plate thickness ratio for circular flange in pure bending

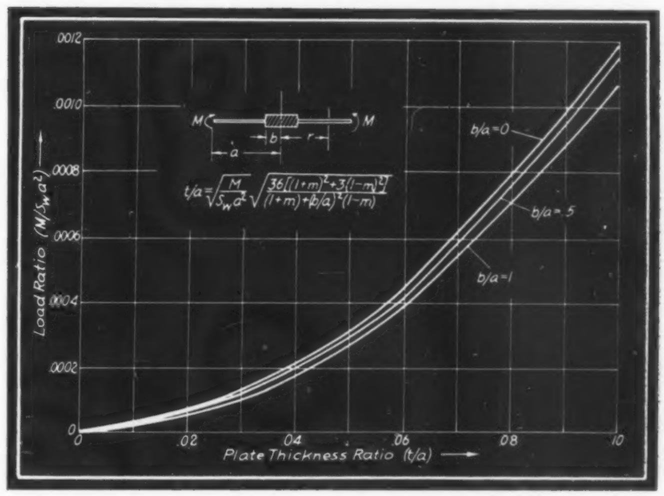
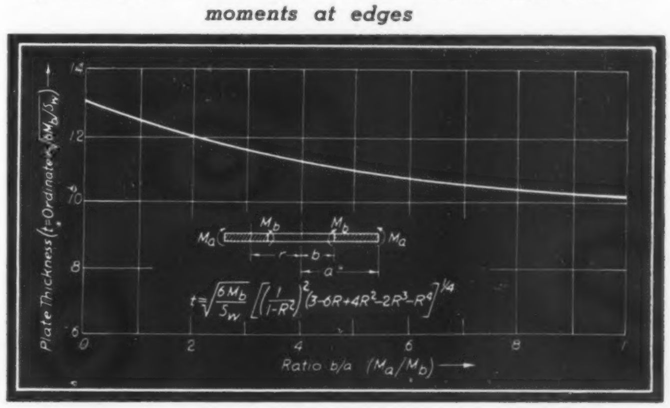


Fig. 5—Below—Plate thickness for annular disk with moments at edges



$$V'_{(\max)} = k\left(\frac{3qa^2}{8t^2}\right)^2 (1+m)^2 \ \ldots\ldots\ldots\ldots\ldots\ldots \text{(g)}$$

or

$$V''_{(\max)} = k\left(\frac{3qa^2}{8t^2}\right)^2 (1+m)^2 \left[\frac{3(1-2m+m^2)}{7+2m+7m^2}\right]. \text{(h)}$$

For all possible values of Poisson's ratio $V'_{(max)}$ is greater than $V''_{(max)}$. By calculus the maximum value of V is given by Equation *g*. The value of V at the outer boundary of the plate must, however, be considered by placing $x = 1$ in Equation *e*. This gives

$$V_{(r=a)} = k\left(\frac{3}{4}\ \frac{qa^2}{t^2}\right)^2 (1-m+m^2) \ \ldots\ldots\ldots\ldots \text{(i)}$$

A comparison of this value with that in Equation *g* shows that it is greater for all possible values of Poisson's ratio. Equating the value of V from Equation *i* to its allowable value in Equation 2, the plate thickness is defined by

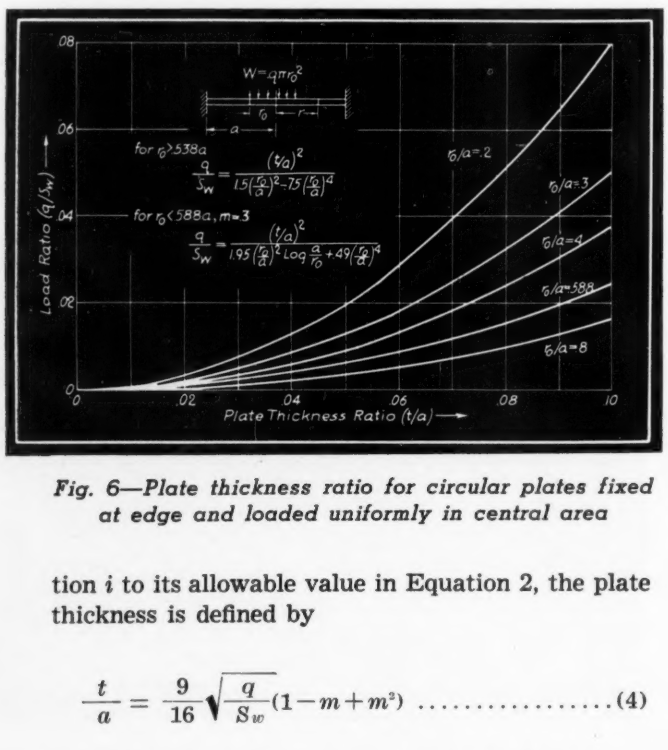


Fig. 6—Plate thickness ratio for circular plates fixed at edge and loaded uniformly in central area

$$\frac{t}{a} = \frac{9}{16}\sqrt{\frac{q}{S_w}(1-m+m^2)} \ \ldots\ldots\ldots\ldots\ldots\ldots \text{(4)}$$

Fig. 2 shows the variation of this plate thickness ratio, t/a, with loading for a value of $m = .3$.

3. Circular Plate Simply Supported At Edge and Uniformly Loaded: If the plate in the previous example is supported, as shown in *Fig.* 3, the bending stresses are

$$S_1 = \frac{3qa^2}{8t^2}\left[(3+m)\left(1-\frac{r^2}{a^2}\right)\right] \ \ldots\ldots\ldots\ldots\ldots \text{(j)}$$

$$S_2 = \frac{3qa^2}{8t^2}(3+m)\left[1-\left(\frac{r}{a}\right)^2\left(\frac{1+3m}{3+m}\right)\right] \ldots\ldots \text{(k)}$$

Using these stress values, the value of the distortion energy is, from Equations *j* and *k*

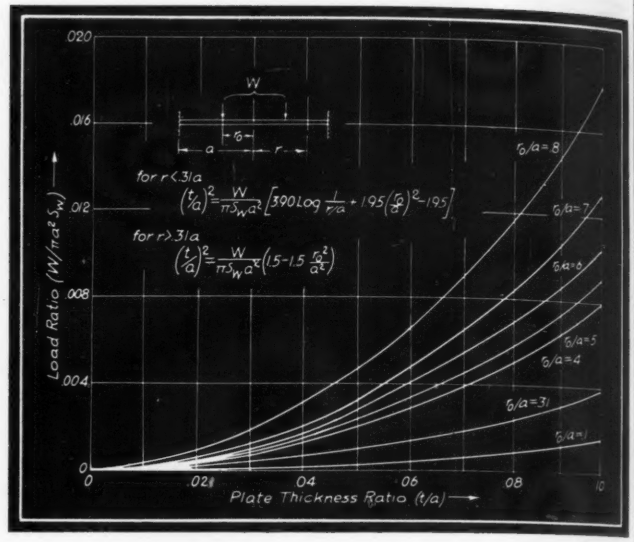


Fig. 7—Thickness ratio for circular plate with concentrated loads as indicated

$$V = k\left(\frac{3qa^2}{8t^2}\right)^2\Big[(3+m)^2 - (3+4m+m^2)\ 4x^2 + (7+2m+7m^2)x^4\Big] \ldots\ldots \text{(l)}$$

Determining the maximum value of V by calculus and considering the values at the boundary, the distortion energy is a maximum for $x = 1$, $x = 0$, or $x = [2(3 + 4m + m^2)/(7 + 2m + 7m^2)]^{1/2}$ The absolute maximum is for $x = 0$ at the center of the plate. The value of this energy is, from Equation *l*

$$V_{(\max)} = k\left(\frac{3qa^2}{8t^2}\right)^2 (3+m)^2 \ \ldots\ldots\ldots\ldots\ldots\ldots \text{(m)}$$

Substituting this value of V for V_w in Equation 2, the thickness of the plate is defined by

$$\frac{t}{a} = \sqrt{\frac{q}{S_w}}\sqrt{\frac{3(3+m)}{8}} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(5)}$$

Equation 5 is plotted in *Fig.* 3 for a value of $m = .3$.

4. Pure Bending of a Circular Flange: The pure bending of a circular flange is shown in *Fig.* 4. At any distance r from the center, the moment along the edge (M per unit length) produces bending stresses of magnitudes

$$S_1 = c\left(c_1 + \frac{c_2}{r^2}\right),\ S_2 = c\left(c_1 - \frac{c_2}{r^2}\right) \ \ldots\ldots\ldots\ldots \text{(n)}$$

where

$$c = \frac{M}{(1+m) + \frac{b^2}{a^2}(1-m)}$$

$$c_1 = (1+m)\,,\; c_2 = (1-m)$$

The distortion energy for the element at r is given by Equations 1 and n. Its value is

$$V = c^2k\left(c_1^2 + \frac{3c_2^2}{r^4}\right) \qquad \text{(o)}$$

By inspection of this equation, V is a maximum when r is a minimum, or for $r = b$. That is

$$V_{(\max)} = c^2k\left(c_1^2 + \frac{3c_2^2}{b^2}\right) \qquad \text{(p)}$$

Equating this equation to the allowable value $V_w = kS_w^2$, the plate thickness is

$$\frac{t}{a} = \sqrt{\frac{M}{S_w a^2}}\sqrt{\frac{36[(1+m)^2+3(1-m)^2]}{(1+m)+\left(\frac{b}{a}\right)^2(1-m)}} \qquad \text{(6)}$$

Fig. 4 shows the variation in the plate thickness for different ratios of b/a and for a value of $m = .3$.

5. Circular Plate with Central Hole Subjected to Bending Moments Along the Edges: There are several engineering constructions in which circular plates with central holes are used, for example, Kingsbury thrust-bearing plates; diaphragms in telephones, loud-speakers, steam turbines, piston heads and cylinder heads[2,3]. An example of this type of plate is illustrated in *Fig.* 5. For this problem the bending stresses are

$$S_1 = c_1' - \frac{c_2'}{r^2} \qquad \text{(q)}$$

$$S_2 = c_1' - \frac{c_2'}{r^2} \qquad \text{(r)}$$

where c'_1 and c'_2 are the following

$$c_1' = \frac{6(a^2M_a - b^2M_b)}{t^2(a^2-b^2)}$$

$$c_2' = \frac{6a^2b^2(M_a - M_b)}{t^2(a^2-b^2)}$$

Proceeding as in the above examples, the distortion energy for an element at a distance r is, using Equation 1

$$V = k\left(c_1' + \frac{3c_2'}{r^4}\right) \qquad \text{(s)}$$

The maximum value of V is, by inspection, for a minimum value of r, or for $r = b$. That is

$$V_{(\max)} = k\left(c_1' + \frac{3c_2'}{b^4}\right) \qquad \text{(t)}$$

The plate thickness can now be found by equating the right-hand sides of Equations t and 2 or

$$t = \sqrt{\frac{6M_b}{S_w}}\left[\left(\frac{1}{1-R^2}\right)^2(3-6R+4R^2-2R^3+R^4)\right]^{\frac{1}{4}} \qquad \text{(7)}$$

where $R = M_a/M_b = b/a$. The plate thickness values, given by Equation 7, are plotted in *Fig.* 5 in terms of the load ratio R which is also the ratio b/a.

Other types of loading on circular plates may be considered in a similar manner but some problems become involved. *Figs.* 6 to 9 give design charts for circular plates loaded and supported as indicated in the figures. For purposes of simplification the stress theory was used for these charts. Diagrams for rectangular plates have been presented by Wojtaszak[4]. For plates of other shapes and loadings, diagrams similar to those given in this paper can be constructed.

[2] For a discussion of various cases and for some design charts using the stress theory see "Stresses and Deflections in Flat Circular Plates with Central Holes"—A. M. Wahl and G. Lobo, *Transactions* A.S.M.E., 1930, Page A.P.M. 52-3.

[4] "Stress and Deflection of Rectangular Plates"—I. A. Wojtaszak, *Transactions* A.S.M.E., Volume 58, 1936, Page A-71.

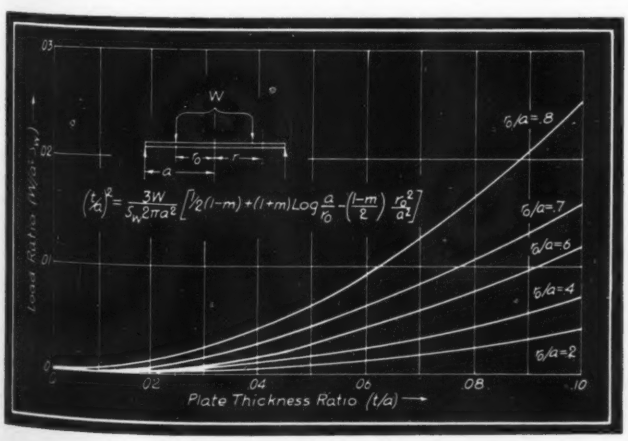


Fig. 8—Thickness ratio for simply supported circular plate with concentrated loads as shown

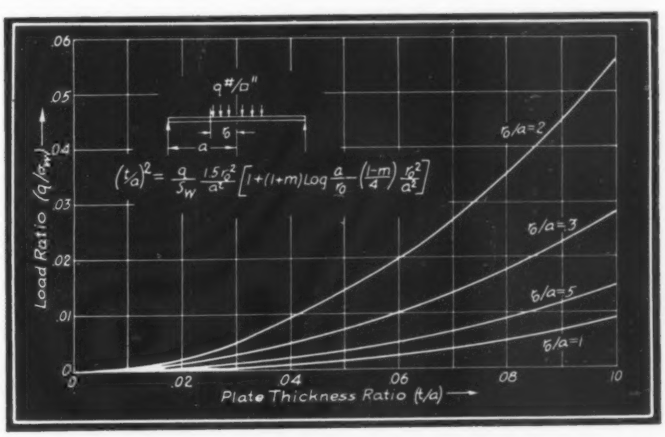


Fig. 9—Thickness ratio for uniformly distributed load over central area for simply supported circular plate

Cost Factors Governing Design for Plastics

By John Delmonte
Plastics Industries Technical Inst.

Fig. 1—Gears utilize both molding and machining for economical production and specifibation

ADAPTATION of plastics to numerous machine designs necessitates careful study of cost factors. On a pound basis, some plastics may appear to be expensive compared with metal equivalents but, when total production costs are analyzed, advantages will become apparent in speed of production and minimum number of finishing and handling operations.

The majority of plastics are shaped into finished parts by molding under pressure. Before production starts however, there are costly molds to make and, in some cases, valuable time is lost before the molds are ready for use. Under some circumstances it is more economical to produce pieces by machining or punching operations rather than by molding. Often for various reasons a combination of molding and machining proves best, as illustrated by *Fig.* 1. The merits of each operation will be apparent from the comparisons to follow. Cost factors involved in the molding and machining of plastics are analyzed, typical problems compared and solutions offered.

MATERIAL COSTS: Representative costs of molded plastics are shown in TABLE I. Cost per cubic inch is based upon the maximum possible range as shown in the first and second columns of the table and does not necessarily represent highest and lowest costs for each group. Costs for molded pieces are of course determined by

Material cost = *Density* × *Price* × *Volume*

= 62.4 × *Specific gravity* × *Price* × *Volume*

where density is in pounds per cu. ft., price is in dollars per pound, volume is in cu. ft.

For injection molding, as much as 25 per cent must be allowed for scrap loss in sprues and runners, though the darker, opaque thermoplastics may be reground and molded together with first run stock. Compression molding of thermosetting materials has lower scrap loss than injection molding, usually less than 5 per cent. Ordinarily this scrap cannot be reground and reused. In special cases however a substantial amount of scrap may be utilized without materially affecting the strength of the

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Phenolics	1.3 -1.9	$.15-.30	$.007-.021
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Polystyrenes	1.05-1.07	.45-.55	.017-.021
Acrylics	1.18	.60-.70	.039-.046

molded part resulting from this process.

Mold Costs: Much of the success of large production items is due to the care and skill with which molds are designed and made. For meeting production schedules the number of cavities designed into a mold is determined by:

1. Weekly production rate
2. Total production requirements.

Often the production rate is the determining factor and, if a piece requires a three-minute molding cycle and a production of 80 pieces an hour, four cavities must be placed in operation to maintain the schedule. When parts are not too large, single-cavity molds can be made in a fraction of the time required for multiple-cavity molds and placed in a fully automatic molding machine for immediate operation.

Mold costs may be expressed as

$$\textit{Mold cost} = A + Bx$$

where A represents fixed initial cost; B, cost per cavity; x, number of cavities.

An alternative suitable for experimental, small volume production is the zinc alloy type of plastics mold developed by the writer. These are cast approximately to size and hand finished to the required smoothness. They are easily made and produced on short notice.

When hobbing methods can be used the cost per cavity falls off considerably as more cavities are added. Steel molds vary in price from as low as $100 to as high as $5000, depending upon the machine work involved and the complexity of the design. Production molds are hardened to resist abrasive action of molding material and of mold parts working against one another which might otherwise cause undue wear, affecting accuracy of part.

Labor Costs: For semiautomatic molding involving manual loading of material and removal of finished parts, labor cost per unit piece naturally decreases with more cavities in the mold. The same mold-closing time and the same cure time is required for ten parts as for four. In some molding establishments a press operator handles more than one press, and while one set of molds is curing the operator gives his attention to the unloading of another press. To accomplish this satisfactorily requires efficient management and planning of schedules. It will be found expedient to forestall any delays by providing operators with ample fixtures for handling of the molding material and of the finished molded parts.

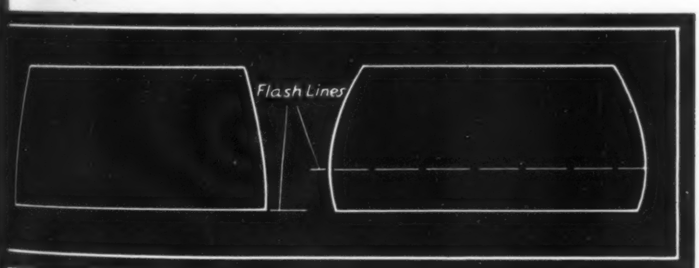

Fig. 2—Judicious design and location of flash line contribute toward low unit cost

Fig. 3—Below—Factors controlling cost of molded parts. Cost factors are shown at left for varying volume of production and at right for fixed volume

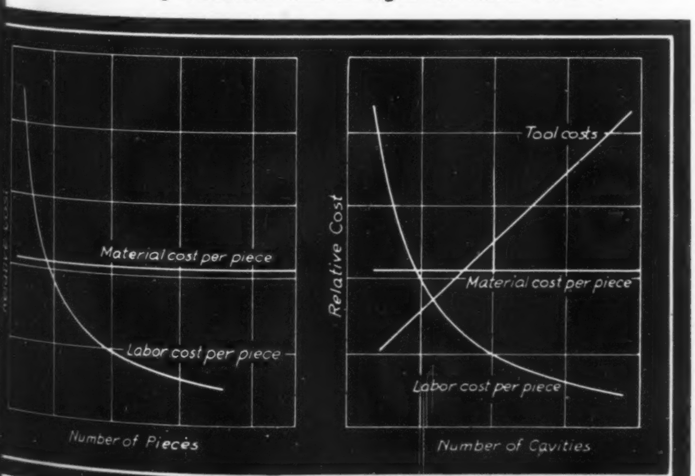

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Table II

Comparative Production Costs

Number of parts	100	1000	25,000
Mold cost	$250	$450	$750
Number of cavities	1	2	4
Daily production	80	160	320
Set-up charge	$25	$25	$25
Material cost (total)	$5	$50	$1250
Material cost (per piece)	$.05	$.05	$.05
Direct labor cost (total)	$8	$40	$500
Direct labor cost (per piece)	$.08	$.04	$.02

Not included in the above analysis are indirect labor and finishing costs, as well as molding room burden and factory overhead. The latter are generally figured on the basis of the number of hours required.

Various cost factors are summarized in *Fig.* 3. On one part of the curve the effect of total production on labor costs and tool costs is portrayed. Total tool costs for maintaining efficient production will rise with production, but there still may be almost a five to one total cost differential per piece for a small production of 100 as compared with a 10,000 production. Also shown in *Fig.* 3, are cost factors for a fixed production, giving the effect of different numbers of mold cavities on the cost. It is apparent that there is a particular number of mold cavi-

Cost Factors Governing Design for Plastics

By John Delmonte
Plastics Industries Technical Inst.

Fig. 1—Gears utilize both molding and machining for economical production and specifibation

ADAPTATION of plastics to numerous machine designs necessitates careful study of cost factors. On a pound basis, some plastics may appear to be expensive compared with metal equivalents but, when total production costs are analyzed, advantages will become apparent in speed of production and minimum number of finishing and handling operations.

The majority of plastics are shaped into finished parts by molding under pressure. Before production starts however, there are costly molds to make and, in some cases, valuable time is lost before the molds are ready for use. Under some circumstances it is more economical to produce pieces by machining or punching operations rather than by molding. Often for various reasons a combination of molding and machining proves best, as illustrated by *Fig.* 1. The merits of each operation will be apparent from the comparisons to follow. Cost factors involved in the molding and machining of plastics are analyzed, typical problems compared and solutions offered.

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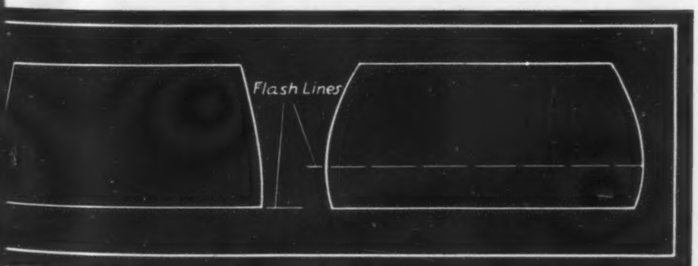

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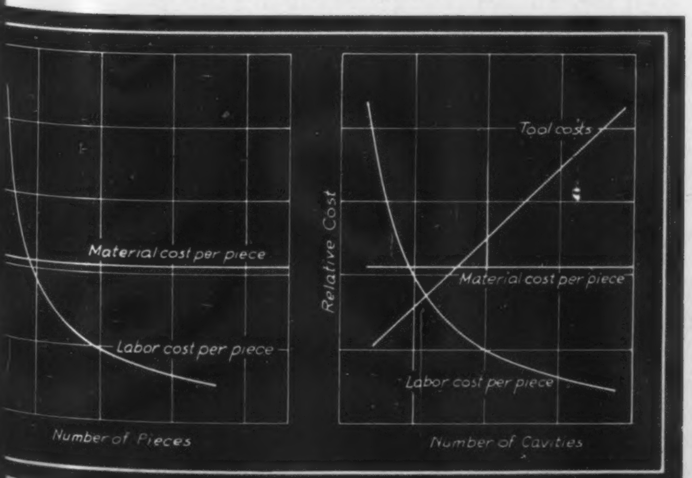

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ties which will make the total cost lower than for any other combination.

Cost factors are also revealed in TABLE II, covering production of a molded throttle lever handle in quantities of 100, 1000 and 25,000. A total molding cycle time of six minutes (including loading, curing and unloading mold) is assumed. Representative values are assumed for mold costs as shown in the table.

MACHINING VS. MOLDING: From the brief review of cost factors involved in molding it is obvious that limited productions must of necessity entail the highest costs. In the fulfillment of wartime measures, standardization by a number of companies upon certain items will make them available at low cost. Airplane pulleys for supporting control cables are typical. However, when individual production requirements of a few hundred or thousand are entailed the economical aspects of plastics production cannot be realized.

Machining from Standard Shapes

Under such circumstances it may be more judicious to machine the part from sheet, rod or tube stock rather than to invest in costly steel dies for molding under pressure. In some circumstances, casting of liquid resins in inexpensive molds may be the best procedure. In others, an examination of the production may reveal that molding accompanied by machining offers the best solution. The subsequent procedure will often be dictated by the design features of the molded article and may be determined by considering the following possibilities.

COMPLETE MACHINING OF PLASTICS: While no mold costs are entailed when parts are machined from sheets or rods, it must be remembered that sheets, rods and tubes average from three to five times higher cost per pound than molding materials. Notwithstanding, small cams, *Fig.* 4, for interrupting electrical circuits in a distributor are best sliced from a long rod of the special cross section illustrated. This can apply only to articles of uniform cross section. As machine time and operations become more restricted, however, the machining of industrial parts should be minimized. This points to increased use of molds and adaptations of standard available shapes.

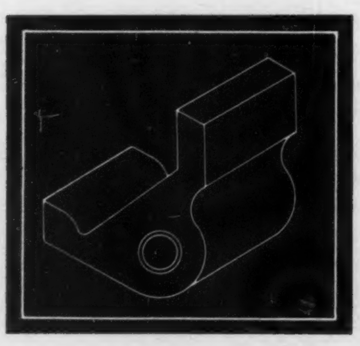


Fig. 4—Extruded sections often offer a solution to a difficult design problem

Punching of plastic parts such as washers, radio tube bases, insulating strips, dial faces, etc., is another fast production method, though confined to flat shapes. Plastics which lend themselves to punching are limited to sheets of laminated phenolics and cellulose derivatives. Drawing of thin-walled containers may also be effected from thermoplastic sheet stock, provided the material has been heated before insertion into the drawing and forming die.

Machining of plastics differs from practices observed for metals. Plastics do not conduct the heat from the cutting tool as do metals. Therefore tool tips will run much hotter, making high-speed tool steels preferred. Further, the design of tools must provide rapid and complete elimination of chips. For example, drills for plastics have wider spaced flutes than for metal. Faster drilling time is thus made possible.

Materials available in sheet, rod and tube form for defense work are:

1. Laminated phenolics and some cast phenolics
2. Cast acrylic plastics
3. Laminated melamine sheets
4. Cellulose acetate and nitrate (thinner sheets)
5. Polyvinyl chloride acetate (thinner sheets).

MOLDING AND MACHINING: Under some circumstances it is more feasible to mold a plastic part and then perform machining operations. This practice is imperative when exacting tolerances are to be maintained. For example, eccentricity tolerances in molded plastic housings for motor bearings must often be held to less than $\pm$.001-inch. It is difficult to mold to this accuracy by compression methods and, rather than be confronted with a number of rejects, molders prefer to mold slightly oversize and machine the molded part to the required tolerance.

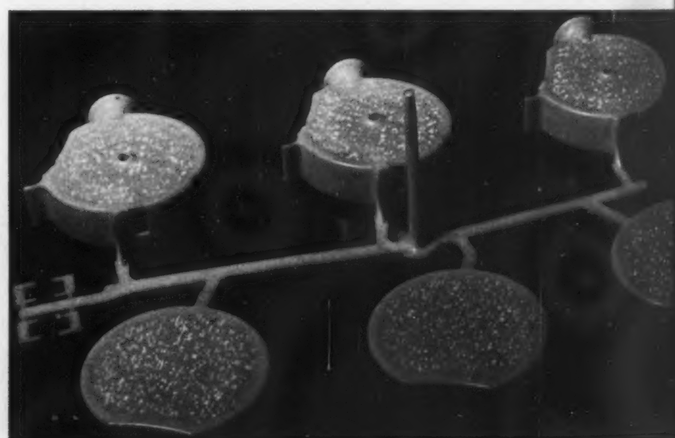


Fig. 5—Projector parts, produced in multiple-cavity molds, have advantages of higher production methods by combining parts in one mold

Machining of molded parts not only permits the attainment of close tolerances but also circumvents

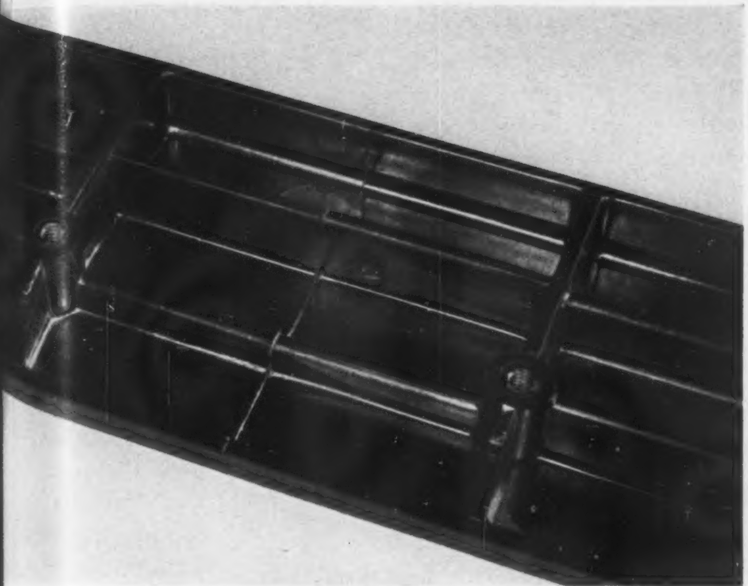
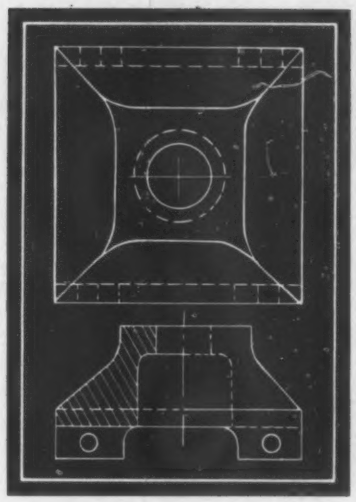


Fig. 6 — Left — Well - designed part has adequate reinforcing ribs and employs machined inserts

Fig. 7 — Right — Machining of holes in molded bracket simplifies mold construction as well as providing greater accuracy of part



the necessity of costly molds or troublesome undercuts. For example, in *Fig.* 7 a bracket and bushing guide is illustrated. The part may be reproduced as shown in the sketch but the advantages of machining are indicated. It seems desirable to machine the four holes in the mounting lugs because this will simplify the mold construction considerably and insure greater accuracy of dimensional tolerances between the center lines through the holes. Obviously in molding, shrinkage (usually .004 to .006-inch per inch) must be allowed for, but this may be slightly variable. Hence if absolute accuracy is imperative, the holes should be machined or drilled in place. Further, if a close tolerance is required inside the large center opening, it is better to moid the hole undersize and machine to the required tolerance.

Methods Effect Savings

Economies may sometimes be realized in the mold construction by molding several parts of different sizes and shapes in the same mold. For example, in the injection molding shown in *Fig.* 5 three different parts are illustrated for a toy motion picture projector injection molded of polystyrene. Good design features are illustrated also in *Fig.* 6 showing reinforcing ribs distributed throughout a molded part and screw machine inserts for attachment purposes.

Aside from machining practices, there are certain finishing operations involving the application of external decorative features which are accomplished at lower cost outside of the mold rather than during the molding cycle. For example, a small molded disk measuring two inches in diameter and ¼-inch in thickness was molded with letters and designs appearing on the outside periphery. This necessitated mold cavities split four ways. In redesigning the piece a straight flat-edge periphery was produced in a simple semipositive mold, and the letters roll-leaf embossed into position. This improved method of production cut the cost of the molded disk in half.

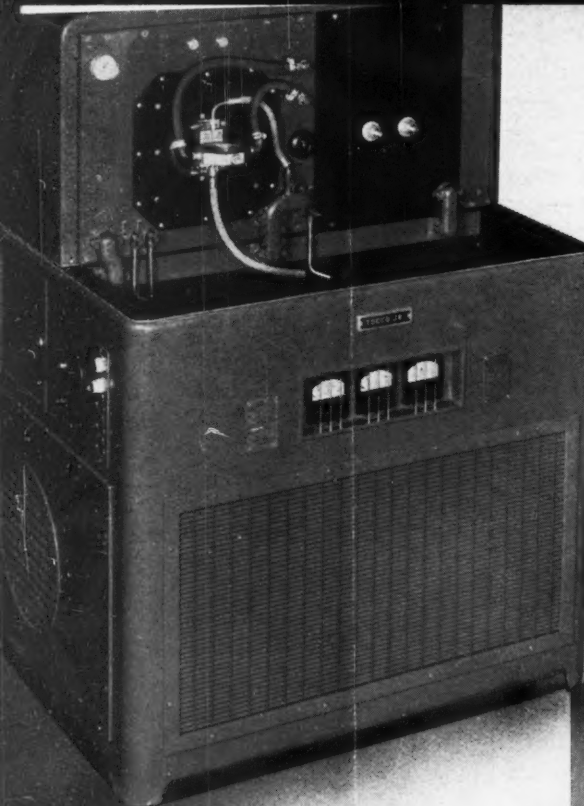
Designers should familiarize themselves with the recently developed techniques of applying decorative treatments to plastics, as well as the numerous attachment devices. Real economies can be effected through a combination of ideas, particularly where costly molding operations can be avoided by machine or fabrication work on the plastic outside of the mold.

He Kept 'em Flying

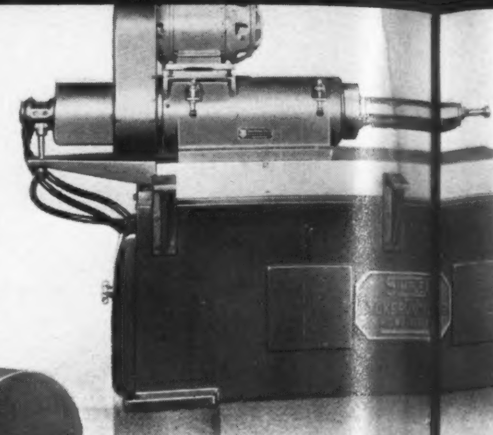
In the early days of aviation Glenn L. Martin was known as the "flying dude". He is shown in one of the early models built by himself. Lacking

protection, instruments and other advantages of today's planes, Martin, as well as Curtiss, Beachey, Fish and others, set world records in craft like this.

Having built his first powered airplane in 1909, Martin's early exploits included: Flying the first airmail, throwing bombs from an airplane, making first extended over-ocean flight.



Below—Hammond cylindrical polishing machine has been designed to be operated by unskilled labor. All parts are carefully guarded and readily accessible. Various speeds of rotation of work as well as feed are attained by a motor-driven variable speed drive. Mounted on a large spindle with sealed ball bearings, the polishing wheel is quickly adjustable



Above—Simplex machine is center high-explosive shell bo ceeding machining operations. driven by electric motor built i head which is, in turn mount ened and ground bed ways. C for differences in length or thick bodies is provided by an exte drel fitted with two sets of expa

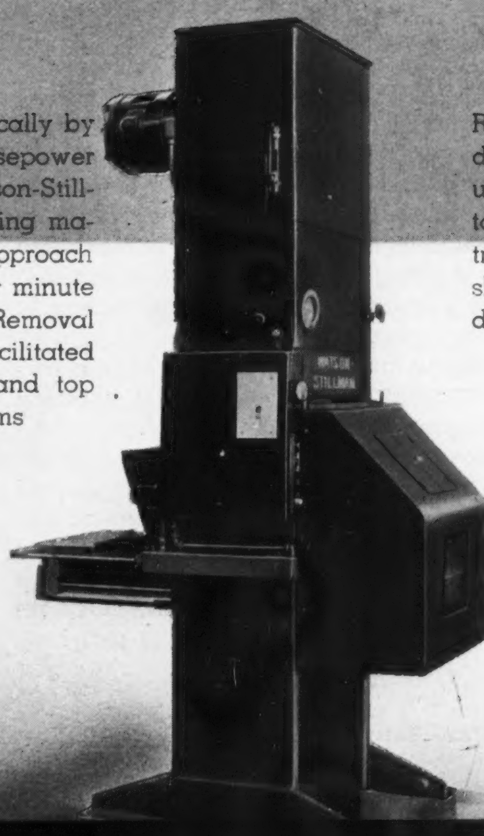
Locating mechanism is sprin

Above—Built-in 9600-cycle high-frequency motor-generator set, operating on a 220-volt feeder line permits high speed induction heating for brazing, hardening or shaping machine parts for the war effort. Control of heating and hardening cycles is attained automatically in Tocco machine

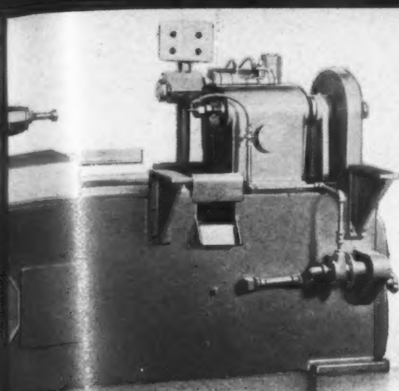
Below—Ten-fold increase in Vultee aircraft plane production is attributable in large part to these 2000-ton Birdsboro hydraulic presses. Operation is expedited by circular work table that successively carries platens of work to the ram. Fast descent, and quick return are obtained

Machines Behi

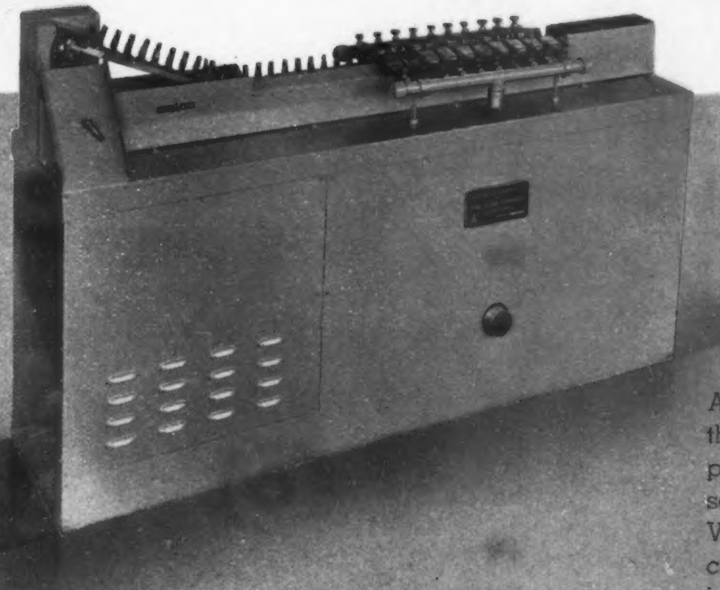
Right—Driven hydraulically by means of a five horsepower pump this 75-ton Watson-Stillman compression molding machine has a ram approach speed of 210 inches per minute over a 10-inch stroke. Removal of finished parts is facilitated by means of bottom and top ejector mechanisms



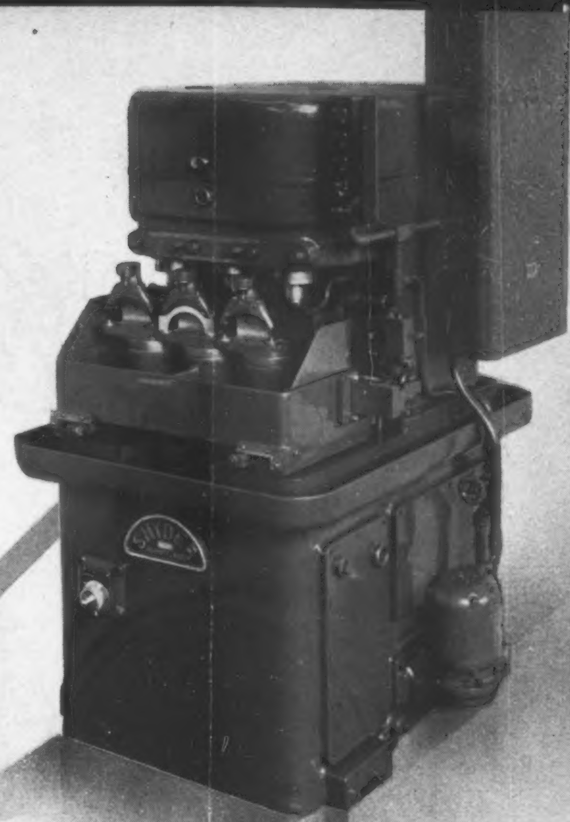
Right—All-electric control of moto driven spindles and hydraulic drillin units of Barnes drilling machine is o tained with centrally located Clark co trols. Specially built to drill propell shafts, machine is equipped with i dexing fixture for drilling twelve hole per shaft, two at a time



Below—Accurate control of flame annealing in Selas machine for processing the threaded end of a forged and hardened tierod ball is attained by keeping the ball end completely immersed in a water bath for the full length of its travel. Each burner is fed with precisely premixed air and natural gas. Drive is through a worm-gear reducer and variable speed V-belt pulley utilizing a quarter-horsepower motor



machine is designed to osive shell bodies for succeeding operations. Spindle is c motor built into the work n turret mounted on hardd bed ways. Compensation length or thickness of shell ed by an extensible manvo sets of expanding plugs. anism is spring loaded



Above—Designed to machine, three at a time, the radius contour of the bolt bosses on airplane engine connecting rod caps this Snyder semiautomatic milling machine is driven by V-belts through spur gears running in oil. Accurate trouble-free operation is obtained by ball bearing-mounted, quill-type spindles employing a vertical adjustment to compensate for tool wear

ehind the Guns

Below—Capable of finishing gears up to 4 feet in diameter and 20-inch face width this Michigan machine is the largest gear shaver ever built. Used exclusively in war production, three cone-type drives are employed, two in the main work drive and one for the feed. Reversible and infinitely variable speed of the spindle is attained with a direct-current motor

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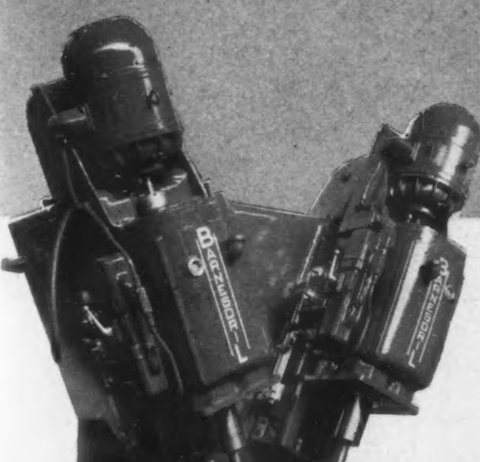
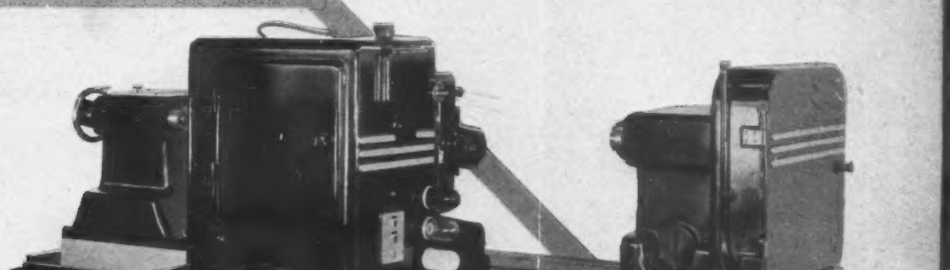




MACHINE DESIGN *Editorial*

Ten Silver Months To Go!

TODAY the word of the hour in American industry is "conversion." It is the key to the swift upsurge in production for war that is essential to victory for the United Nations.

Donald M. Nelson, able head of the War Production Board, makes an iron-clad case for conversion on these points:

The task of American industry is tremendous. Already the United States has turned out more of certain war items than in World War I, but this is not enough.

Americans have been smug. They have been complacent in the thought that they can "swamp the enemy with mass production."

American industry can do just that—when it gets started. It is only now getting started.

The months of golden opportunity have been lost, reasons Mr. Nelson. Months in which the nation might have expanded industrial capacity to cope with the job ahead are gone. Now the urgency is so acute that the United States cannot wait for new capacity. The nation must do the best it can with what it has.

So, he concludes, having squandered away the priceless months of golden opportunity, the country has left in this critical year of 1942 only ten months—ten months, not of golden opportunity, but of silver opportunity.

What can Americans do in these ten remaining silver months that will be most effective?

They can convert American industry to wholesale production for war. They can scale American living down to a "lean but sound economy" and devote all remaining resources to war.

Conversion involves getting far more production out of facilities already engaged in war work, placing idle facilities and those now working on non-essentials at work on war essentials, and progressively moving each war goods contractor up from simple war work to the most complex and difficult war production of which he is capable.

All three of these phases of conversion involve problems in which machine design plays an important part. The need for speed in production and the scarcity of certain materials present a greater challenge than ever before to American design ingenuity.

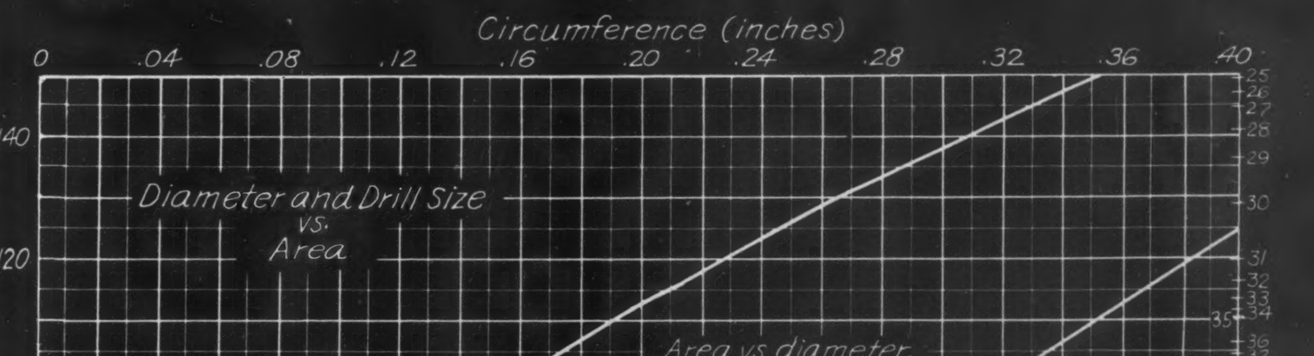
Ten silver months! Ten silver months for designers of machinery to help their companies work miracles in conversion!

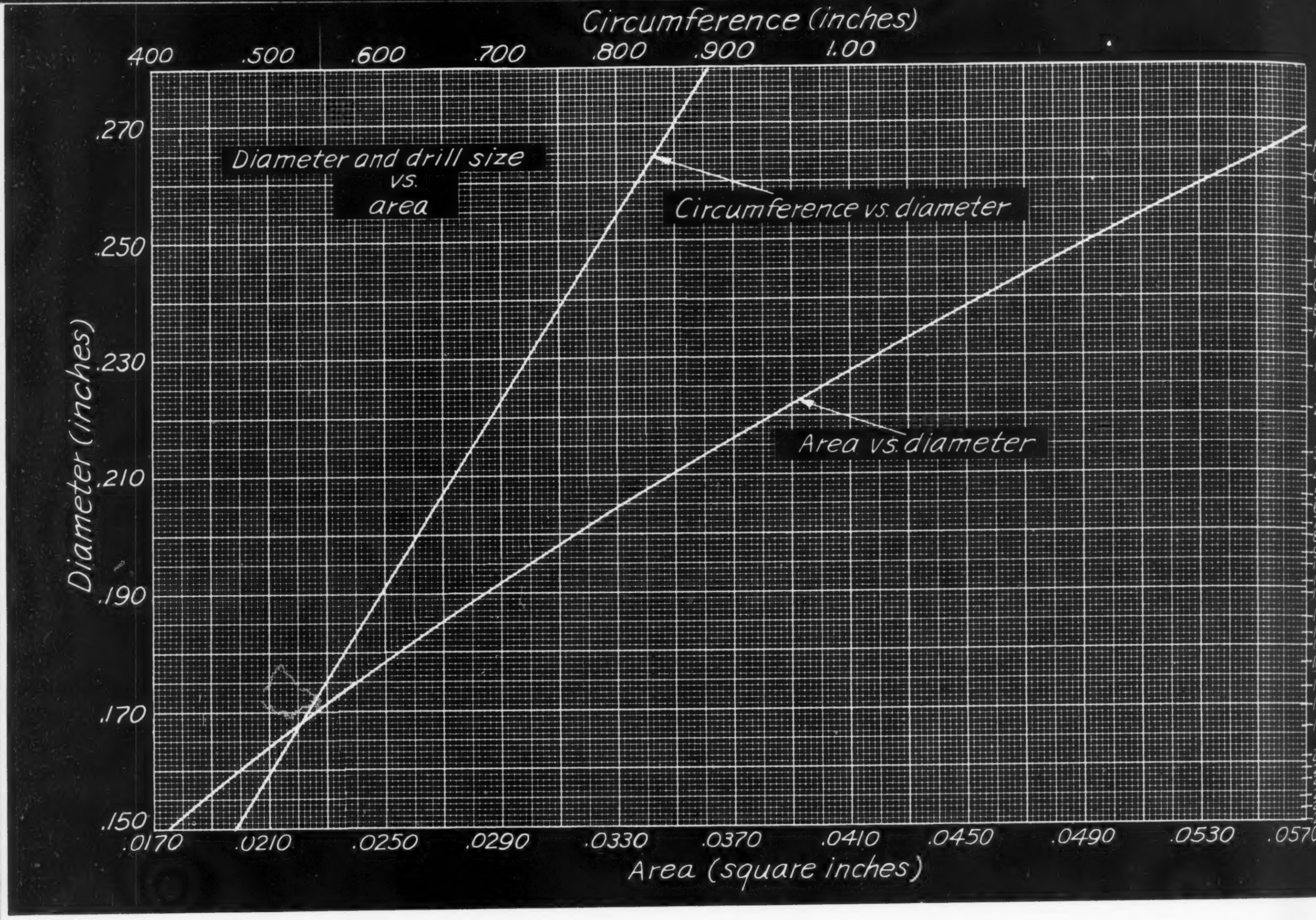
E. L. Shaner

Circumference, Area, Diameter of Drill Sizes

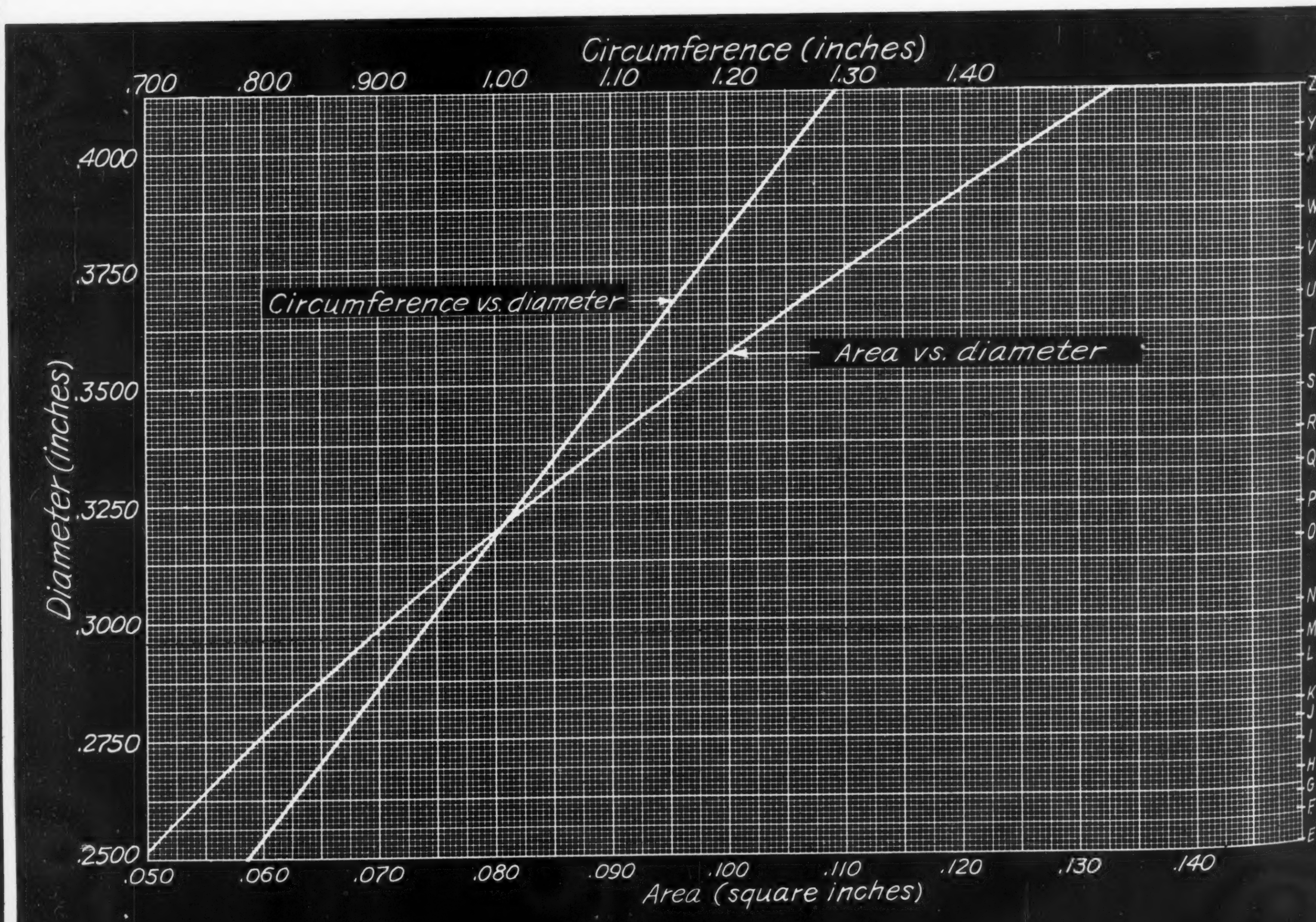
IN MANY engineering computations quick reference to values of diameter, area and circumference of number and letter drill sizes is a distinct convenience. For example, in obtaining the total shear area of rivets, in orifice flow measurements, in determining the strength of mechanical links of circular cross section, etc., ready availability of such values saves considerable time.

To fulfill this need the following three charts are presented. As indicated, the left and right ordinates are in terms of diameter and drill size respectively. The lower abscissa is in terms of area and the upper, of circumference. Thus, at a glance, the complete data for any drill size from number 80 to letter *Z* is obtainable.





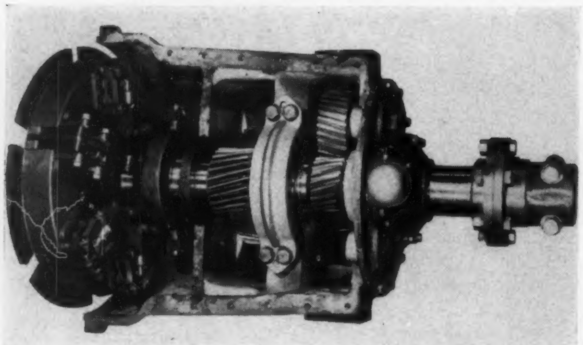
Circumference (inches)
.400 .500 .600 .700 .800 .900 1.00
Diameter and drill size vs. area
Circumference vs. diameter
Area vs. diameter
Diameter (inches)
.270 .250 .230 .210 .190 .170 .150
.0170 .0210 .0250 .0290 .0330 .0370 .0410 .0450 .0490 .0530 .0570
Area (square inches)



Circumference (inches)
.700 .800 .900 1.00 1.10 1.20 1.30 1.40
Circumference vs. diameter
Area vs. diameter
Diameter (inches)
.4000 .3750 .3500 .3250 .3000 .2750 .2500
Z Y X W V U T S R Q P O N M L K J I H G F E
.050 .060 .070 .080 .090 .100 .110 .120 .130 .140
Area (square inches)

Applications

of Engineering Parts and Materials



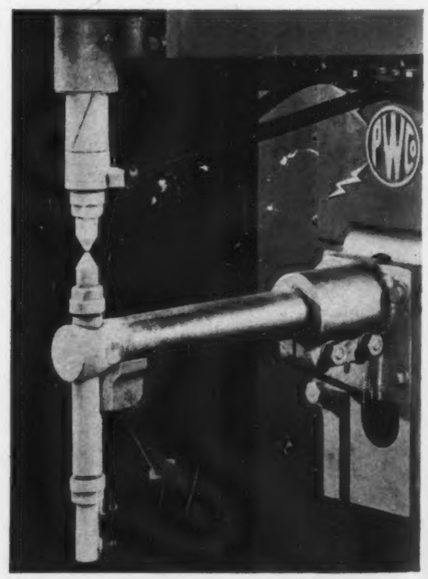
Gear Changes Eliminated

COMBINING the functions of a clutch and reverse gear the marine reduction unit illustrated is contained within a single housing integral with the Gray diesel engine. Combination of forward and reverse operation is made possible by the use of two separate Twin-Disc clutches arranged to provide a positive neutral, known in marine work as a "sailing clutch". When installed on an auxiliary which is under sail the propeller is permitted to spin freely.

Both clutches are operated by an exactly similar spring-loaded, overcenter mechanism, providing the same type of engagement in both directions. Reduction gears are of the helical type and are constantly in mesh. Both radial and shaft loads are carried by oversized ball bearings.

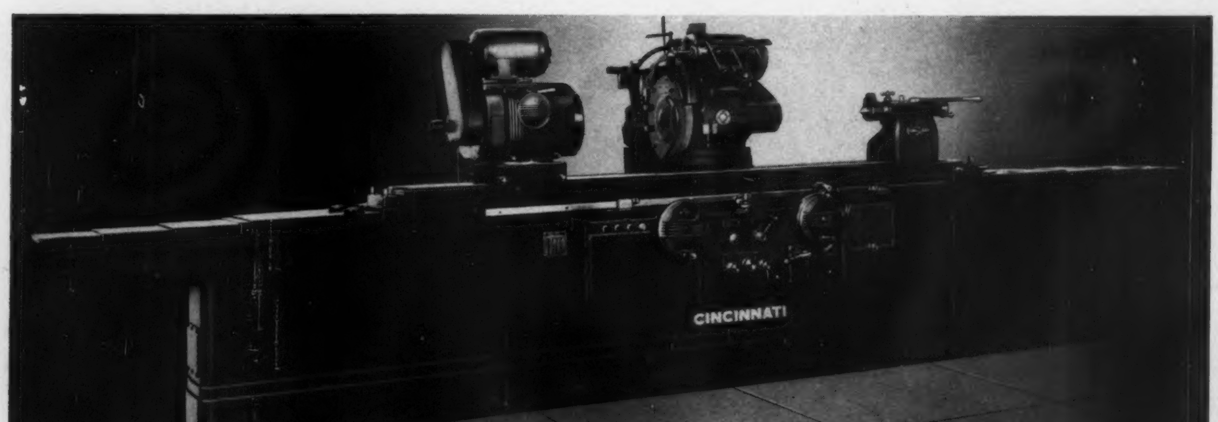
Electrode Efficiency Enhanced

ELIMINATION of heat softening and consequent deformation of the welding electrodes of spot welding machines is made possible by the application of refrigeration to the electrodes. This development of the Progressive Welder Co. enables continuous runs of ten minutes duration and a welding rate of 100 welds per minute to be made without point dressing. While the refrigerating units absorb considerable heat, welding machine settings are actually lower than with water cooling.



Excludes Dust and Grit

NECESSITY of preventing access of abrasive particles to the accurate ways of grinding machines has given rise to a number of ingenious methods for their protection. In the Cincinnati machine illustrated this is accomplished by means of telescopic way guards. Entrance of abrasive particles between the sections of the guard is prevented in two ways: First, by supporting each of the telescopic sections on tiny rollers, minimum clearance is attained. Second, by use of an oil pump distributing lubricant through grooves, any foreign matter is washed off.

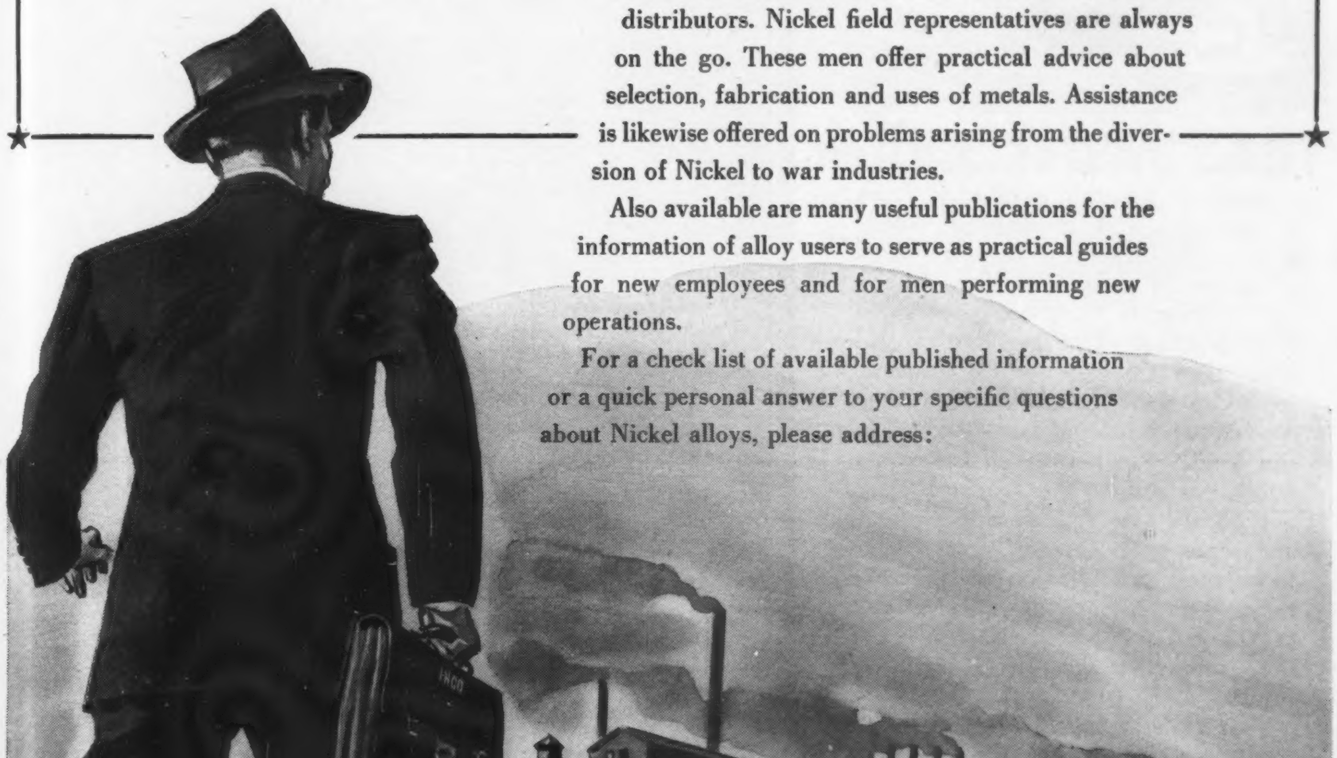


ON THE MARCH to aid users of alloys...

FIELD offices are maintained by International Nickel's Development and Research Division and by qualified distributors. Nickel field representatives are always on the go. These men offer practical advice about selection, fabrication and uses of metals. Assistance is likewise offered on problems arising from the diversion of Nickel to war industries.

Also available are many useful publications for the information of alloy users to serve as practical guides for new employees and for men performing new operations.

For a check list of available published information or a quick personal answer to your specific questions about Nickel alloys, please address:



NICKEL

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK, N. Y.

Lubricating Ball Bearings

FULLY appreciating the many problems that are faced by ball bearing users in specifying and obtaining suitable greases for ball bearings, the Annular Bearing Engineers' Committee has been undertaking, over a period of several years, a research program conducted from a chemical and mechanical standpoint. The report of the committee is abstracted in the following. Lubricant standards have been developed from practical experience and careful analysis, but it may become desirable to revise these occasionally to keep abreast of continual development in the field. Further, some lubricants which conform to the standards may not be suitable for all applications, and some greases which do not conform may occasionally be satisfactory. For all applications, the user of the bearing is advised to obtain the approval of the grease manufacturers.

Two general types of greases are recommended, A.B.E.C.-I and A.B.E.-C-II. Their properties are specified in TABLE I. The first is recommended for the speeds and temperatures indicated in TABLE II. The second, A.B.E.C.-II, is a general purpose type for grease-gun application and is also suitable for the conditions noted in TABLE II. Both types should be free from dirt, abrasive matter, fillers, excessive amounts of moisture and free acid or free alkali. A water-repellent grease may be required for excessive moisture conditions.

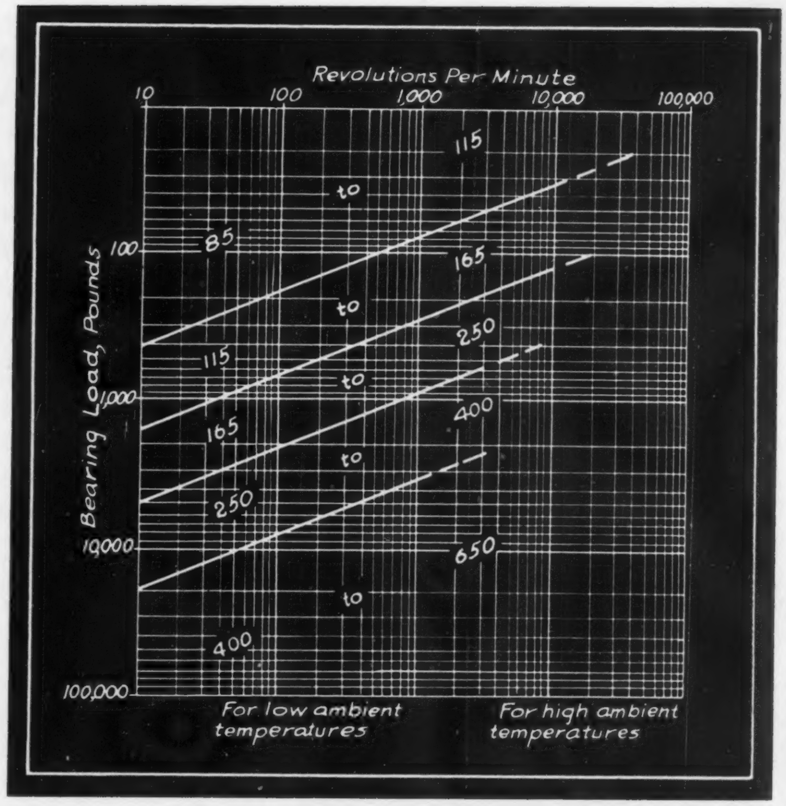


Fig. 1—Chart aids in the selection of proper oil for bearing operating conditions. Ranges of values on the graph are units of viscosity

Greases should show no change in consistency, drop point, or neutralization within the defined limits,* nor more than 5 pounds drop in oxygen pressure following a 100-hour run in an oxidation bomb at 210 degrees Fahr. and 110 pounds initial oxygen pressure, using a 20-gram sample on standard glass sample dishes. When tested under the same conditions with the addition of a piece of sheet copper partially immersed in the sample, there should be no evidence of stain or corrosion of the copper strip, nor any evidence of physical change in the grease after six hours of exposure to the metallic strip.

Friction torque in a bearing is lowest with a small quantity of oil, just sufficient to form a thin film over the contacting surfaces. Friction will increase with greater quantity and with higher viscosity of the oil. With more oil than just enough to make a

*Consistency A.S.T.M. penetration or equivalent and drop point Shell Ubbelohde shall not increase or decrease more than 10 per cent. Neutralization numbers made on grease samples before and after 100-hour accelerated oxidation, or 18 months' storage test, must not show a total change of more than the equivalent of 10 milligrams of KOH per gram of grease, nor shall the neutralization number following 100 hours oxidation show acidity exceeding the equivalent of 5 milligrams of KOH per gram of grease.

TABLE I

Standards for Greases

Property	A.B.E.C.—I	A.B.E.C.—II
Nature of soap	Soda or soda lime; maximum lime soap 5% of total weight of grease; uncombined lime .1% max.	Soda or soda lime; maximum lime soap 5% of total weight of grease; uncombined lime .1% max.
Worked penetration, A.S.T.M.	190 min.	260 min.
Running torque, A.B.E.C. test	60-300 gm.-cm.	60-450 gm.-cm.
Leakage, through plate seal	5% max.	20% max.
left in bearing	75% min.	75% min.
Oxidation	(See discussion)	(See discussion)

film, the friction torque will also increase with the speed.

Energy loss in a bearing is proportional to the product of torque and speed, and this energy loss will be dissipated as heat and cause a rise in the temperature of the bearing and its housing. This temperature rise will be checked by radiation, convection and conduction of the heat generated to

TABLE II

Greases for Ball Bearings†

Operating Temp. Range (Deg. Fahr.)	Speed Factor (Bearing Bore (m.m,) × R.P.M. Up to 75,000	75,000 to 150,000	150,000 to 300,000
−10 to +125	A.B.E.C.-II‡	A.B.E.C.-I	A.B.E.C.-I
+32 to +150	A.B.E.C.-II	A.B.E.C.-I	A.B.E.C.-I
+60 to +200	A.B.E.C.-II	A.B.E.C.-I	

†For speeds and temperatures outside the indicated ranges, no recommendations are made.
‡A.B.E.C.-I may be preferred for some applications.

an extent depending upon the construction of the housing and the influence of the surrounding atmosphere. The rise in temperature, due to operation of the bearing, will result in a decrease in viscosity of the oil and, therefore, a decrease in friction torque compared with the friction of starting, but soon a balanced condition will be reached.

With so many factors influencing the friction torque, energy loss and temperature rise in a bearing lubricated with oil, it is evidently not possible to give definite recommendations for selection of oil for all bearing applications, but two general considerations are dominant:

1. The desire to reduce friction to a minimum, which requires a small quantity of oil of low viscosity.
2. The desire to maintain lubrication safely without much regard for friction losses, which results in using larger quantities of oil and usually of somewhat greater viscosity in order to reduce losses from evaporation or leakage.

This second condition is most frequently met and in view of the broad outline of oil lubrication given above, the chart, *Fig.* 1, has been made up for selection of viscosities of oil for various operating conditions. When ambient temperatures are low the lower viscosity ranges should be used and with high operating temperatures the higher viscosities should be selected. For bearings that have to operate over a wide range of temperatures, an oil having the least changes with change in temperature, i.e., an oil with high viscosity index, should be selected.

In the great majority of applications pure mineral oils are most satisfactory but they should, of course, be free from contamination that may cause wear in the bearing; they should show high resistance to oxidation, gumming and to deterioration by evaporation of light distillates; and they must not cause corrosion of any bearing parts.

It is evident that for low starting temperatures an oil must be selected that has sufficiently low pour-point so that the bearing will not be locked by oil frozen solid.

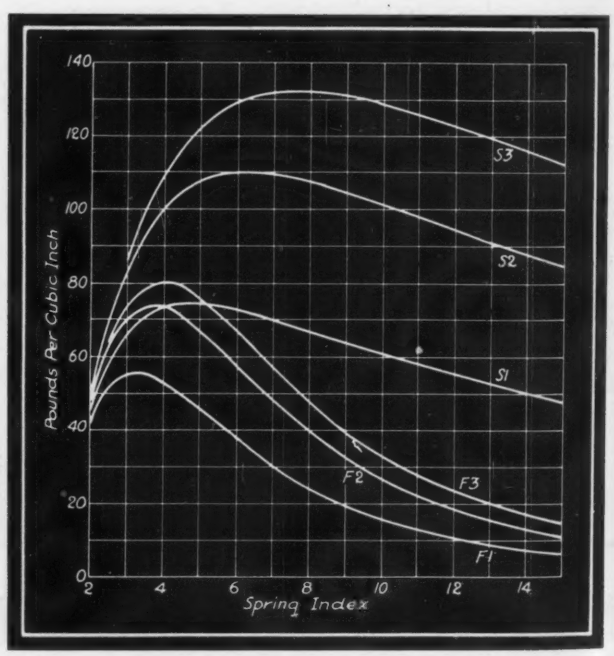
Professional Viewpoints

" . . . bases design on free height"

To the Editor:

Mr. Wahl's article, "Combining Maximum Spring Deflection With Minimum Space," which appeared in your January issue is a valuable contribution to the subject of spring design because it directs thought to a phase not ordinarily considered. The design of a helical spring to meet the load-deflection specifications usually involves a number of trials to establish outside diameter, solid height, diameter of steel and whether it should be a single-coiled or multicoiled spring. There are many combinations of proportions which can be selected to meet the specifications differing somewhat in the choice of the numerous variables.

Curves showing the relationship between energy stored per unit volume of solid-height space and spring index are useful guides in working out a design and aid in the appraisal of springs already determined, by showing whether the best use of the avalable space is accomplished. Where a spring is



Curves for energy stored vs. spring index for active free-height volume of single, double and triple springs shown respectively as F1, F2 and F3. Active solid-height volume is similarly shown as S1, S2 and S

subjected to variable loading it is interesting to note that Mr. Wahl's curves have well-defined maximum points, hence there is a rather narrow choice of index if the space is to be used efficiently.

However, if a spring subject to variable loading

READILY AVAILABLE...

THANKS TO INCREASED DEMAND

Paradoxical? Yes, but true. Torrington Needle Bearings are *available for prompt delivery on your priority orders now* because the demand for them has been increasing so steadily. Again and again, during the eight years since the Needle Bearing was introduced, we have had to expand our facilities to meet this mounting demand—until today *further* expansion is a comparatively simple matter.

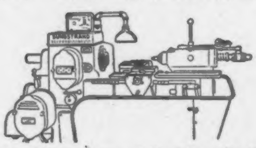
But *why* this increasing demand? The reasons lie in the bearing's unique combination of advantages . . . low cost, small size, high capacity, ease of installation, efficient lubrication. These advantages are so easily demonstrable, so obvious, that they have led to thousands of applications for the Needle Bearing in virtually every branch of industry.

In fact, this bearing's potentialities are so evident that we have been able to anticipate and prepare for the increasing demand with a planned program of expansion. As a result our facilities are keyed to the requirements of Victory—and Torrington Needle Bearings can be supplied promptly for all essential needs.

Here is one way to guard against future production delays—incorporate the Needle Bearing in your designs now. Torrington engineers will help you adapt its advantages to your specific problem. For detailed information, write for Catalog No. 109.

THE TORRINGTON COMPANY
TORRINGTON, CONN., U. S. A. • *Estab. 1866*
Makers of Needle and Ball Bearings
New York · Boston · Philadelphia · Detroit
Cleveland · Chicago · Los Angeles · Seattle
San Francisco · Toronto · London, England

EASE OF ASSEMBLY

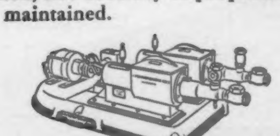


Unit construction of the Needle Bearing facilitates installation in Sundstrand Machine Tool Company's Model 8 Automatic Lathe. The bearing's high capacity in proportion to size permits anti-friction construction in a limited space, results in long service life with little attention.

SUNDSTRAND MACHINE TOOL

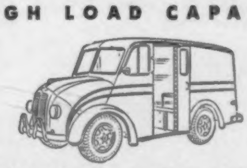
ELIMINATION OF WEAR

Bearing wear is reduced to a minimum by the use of Torrington Needle Bearings on crank pin and wrist pin of the Adjust-O-Feeder, designed for accurate proportioning of fluids. As a result, lost motion is entirely eliminated, and accuracy of proportioning is maintained.



% PROPORTIONEERS, INC. %

HIGH LOAD CAPACITY



The high load capacity of the Needle Bearing permits the use of relatively small sizes for heavy duty applications, permitting substantial savings in weight in aircraft and automotive applications. Typical instance is its use in ratchet assemblies on Divco-Twin Trucks.

DIVCO-TWIN TRUCK COMPANY

is incorporated in a machine for the deflection it affords, its further capacity to store energy is terminated when compressed solid. Thus, the solid-height volume is a minimum limit in the way of space requirements. In order that the spring will have energy absorption capacity, it must be assembled either free or preloaded to only some fraction of the total deflection. Under these conditions, it will obviously occupy more space than is indicated by the solid-height value. While all springs are not assembled free, the precompression will not be large if much energy absorption is expected.

Gives Lower Index

Considering the solid-height volume as the minimum space requirement, then the free-height volume represents the maximum space requirement. If the springs are coiled with a pitch corresponding to 120,000 pounds per square inch when compressed solid, a group of curves may be plotted to give energy stored per unit of free-height space vs. the spring index. These curves will be similar in appearance to those developed by Mr. Wahl. The maximum points, however are shifted to lower indexes and there is a much greater difference between the energy stored at the maximum point and regions of higher index. As an example, for a single coil spring, the maximum point is about 4.8 index when based on the solid-height volume and shifts down to 3.3 index when based on free-height volume. Corresponding changes occur on double or triple coil springs.

It should be appreciated that only the active coils of the spring have been used to define spring volume. The inactive end coils also occupy space and if the spring is relatively low in height and of high index, the inactive coil space grows to important proportions. The inactive coil space is a variable for each design and cannot be stated mathematcally as a function of index only.

Since most springs are installed with some initial compression, the use of curves based on active free-height should be more representative since the error involved in disregarding the initial compression will be more or less offset by not considering the space occupied by the inactive end coils.

—E. Latshaw
The J. G. Brill Co.

"... comments are appreciated"

To The Editor:

Mr. Latshaw's interesting comments on my article are appreciated. The following considerations may serve to supplement his discussion.

For statically loaded compression springs where the springs are compressed nearly solid in practice, the solid-height volume, as used in the writer's article, is in most cases a fair approximation to the actual space taken up by the spring. Hence, for such applications, the use of the solid-height volume appears logical as a criterion of efficiency of space utilization.

However, for the other extreme case where the


5
CERAMICS
ZINC IN WAR
"AN ARMY MARCHES ON ITS STOMACH"
The United States armed forces are not only well fed, but a high degree of cleanliness is maintained in the preparation and serving of the food. White is the symbol of purity, and zinc pigments not only make paint whiter and more durable, they also serve in this capacity in tiling, porcelain enamelware and dishes in Army and Navy kitchens and mess halls.
Zinc oxide is used as a flux in ceramics to provide whiteness and gloss and to resist the shock of sudden temperature changes. Its presence prevents crazing of pottery and chipping of porcelain enamel. In ceramic manufacturing, zinc oxide provides such indispensable formulation features as fusibility, non-volatilization and wide temperature range.
When one considers the number of American soldiers, sailors and marines to be fed "three squares a day"—plus the fact that imports of European ceramic products have been cut off almost completely—the demands for zinc oxide by our ceramic industry can be appreciated.
This is just another one of the normal uses for zinc which has become greatly expanded by war needs — one more reason why civilian users may not be able to obtain all of the zinc they would like to use.
DIE CASTING
METAL SPRAYING
GALVANIZING
PHARMACEUTICALS
NICKEL SILVER
1
HULL PLATES
2
RUBBER
3
PAINT
4
BRASS
U. S. ARMY SIGNAL CORPS PHOTO
THE NEW JERSEY ZINC COMPANY
MANUFACTURERS OF THE FAMOUS HORSE HEAD ZINC PRODUCTS
New Jersey Zinc

spring is under variable loading in a zero to maximum range, the free-height volume as suggested by Mr. Latshaw represents approximately the space required when the spring is unloaded and therefore is probably a more representative criterion than solid-height volume. It should be mentioned, however, that the application of the criterion of free-height volume is complicated by the fact that a value of allowable stress at solid compression must be assumed. This means that the most favorable value of spring index will fall at a different point for different values of stress assumed. Also, if a low stress is used the difference between the results obtained on the basis of the free-height volume and those obtained using the solid-height volume will be less than if a high stress is taken.

In most practical applications, where springs are subject to a considerable amount of initial compression a criterion of space occupied intermediate between the free and solid-height values would appear to be most representative. This, in turn, would depend on the initial compression of the spring as well as on the allowable stress at solid height. For best accuracy, the space occupied by the end coils should also be considered. To avoid all these complications the simple criterion of solid-height volume was used in the article primarily as a convenient guide for judging the efficiency of space utilization.

—A. M. Wahl
Westinghouse E & M Co.

" . . . articles on hydraulics helpful"

To the Editor:

The series of articles in your magazine on fluid devices and circuits by Mr. C. E. Grosser are worthy of serious attention from designers and engineers. It is my opinion that these articles are well worthwhile. They certainly contain a good deal of valuable information which cannot be found elsewhere.

In the past, design material of this sort has been confined largely to a limited number in the industry. I am glad to see that you are helping to bring some of the information out into the open.

—R. C. Binder
Purdue University

" . . . voice opposition to bearings"

To the Editor:

Applications of self-sealed ball bearings are increasing rapidly, according to various reports. Undoubtedly manufacturers made exhaustive tests of the bearings and carried out intensive studies of difficulties of introducing such a radical design.

Some sales departments of machinery companies, however, voice opposition to the use of a bearing which has no means of external lubrication. They claim many responsible maintenance men cannot be convinced of the dependability of such a bearing.

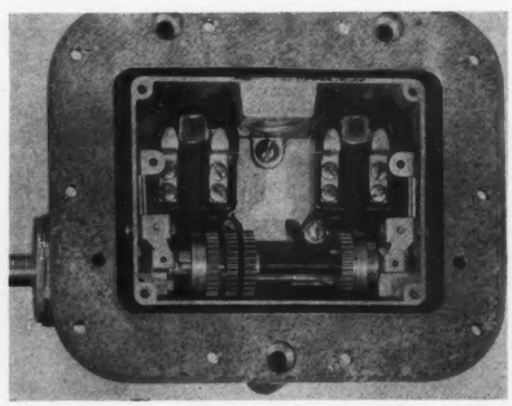
This raises an interesting point and it would be enlightening to hear comments from other readers.

—C. E. Schirmer, *Chief Engineer*
Robins and Myers Inc.

New PARTS AND MATERIALS

Limit Switches of Rotating Type

TWO new forms of rotating-type limit switches have been added to General Electric's line of CR9441-Cp limit switches. One form is for Class 1, Group D hazardous gas locations, and the other for applicatons requiring a watertight switch. Housed in heavy, flanged, cast-iron enclosures, the switch has a mechanism which may be adjusted to operate contacts between a minimum of one-half



turn of the driving shaft and a maximum of 120 turns. Indefinite overtravel will not harm the switch mechanism. Double-break, fine-silver contacts are cleaned by opening and closing with a rocking motion. One double-break contact is located at each end of the travel and can be made normally closed or normally open without additional parts. For easy wiring a large (¾-inch) conduit entrance and roomy box are provided.

Motor with All-Around Protection

DEVELOPED to give complete all-around protection, the motor announced by Allis-Chalmers Mfg. Co., 1126 South Seventieth street, Milwaukee, embodies the "safety-circle" principle which consists of a wide, solid rib—integrally cast as part of the frame—forming an unbroken circle

of protection around the stator. Guarding the motor from exterior knocks and abuse are a one-piece cast frame and cast end-shields. More liberal use of electrical materials makes the motor internally and electrically stronger because current and magnetic densities are less extreme. Improved bearings design delivers smoother performance with full-flow lubrication. For maximum power

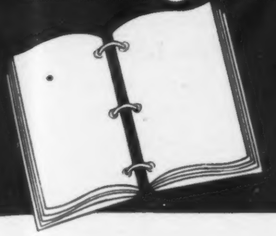
efficiency, additional cross-strength has been built into the distortionless stator. Rotor is keyed to shaft for strength, and its outer surface is turned for smoothness and an accurate air-gap. The motor draws in air at openings to the right and left of each bearing cap. Air is expelled at bottom of motor through openings incorporated in housing between the mounting lugs. Other features are oil drains at bottom of bearings for easy flushing, removable end brackets, and large conduit box for handy wiring.

Range of Rheostat Cages Offered

RHEOSTAT cages have been developed by Ohmite Mfg. Co., 4835 Flournoy street, Chicago, for use with the company's rheostats. The cage enclosure is a convenient form of table-top or surface

mounting, advisable where there is possibility of mechanical injury to the rheostat or human contact with electrically "live" parts. Surface-mounting

Designing Molded Plastics Parts: TOLERANCES



from the engineering files of One Plastics Avenue

Specifications for tolerances in hot molded plastics parts should be dependent upon the following general factors:

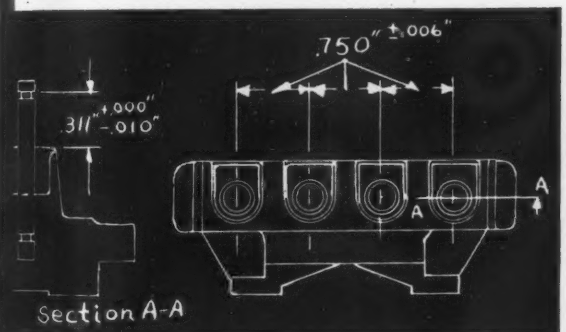
1. **Minimum tolerance of dimensions measured parallel to mold parting line is *plus or minus* 0.003"/-in., but a more practical tolerance is *plus or minus* 0.005"/in.; at right angles to parting line the minimum is *plus* 0.010" and *minus* 0.000", but a more practical tolerance is *plus* 0.015", *minus* 0.000".**

2. **Rag-filled or coarse compounds require greater leeway in "build-up" dimensions (parallel with mold pressure): minimum *plus* 0.015", *minus* 0.000", more on large parts.**

3. **Multiple cavity molds usually necessitate increased tolerances.**

4. **For warpage, *plus or minus* 0.003"/in. from the average plane through the warped surface is a good working tolerance.**

5. **All batches of each grade of compound should be uniform to ensure uniform shrinkage in molded part.**



◄ TYPICAL APPLICATION ►

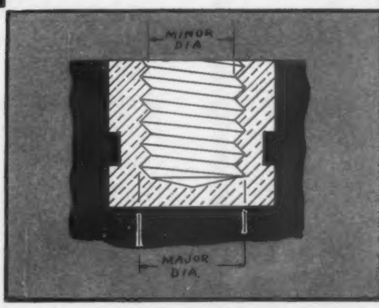
In this hot molded tip support for an electric contactor assembly, a general purpose grade of phenolic compound and proper design of part provides nominal (*plus or minus* 0.006") tolerance between contact tips and close tolerance on metal inserts.

DESIGN CONSIDERATIONS

1. Variations in dimensions of molded parts may be caused by toolroom tolerances, distortion in hardening, mold wear, changes in molding technique.
2. Designer and molder should co-operate on tolerances. Specify tolerances only on important dimensions. A demand for closer tolerances than are necessary increases production costs and reduces output.
3. Warping can often be controlled by use of cooling forms.
4. Shrinkage of parts is compensated for in design of mold. Accurate gages facilitate maintenance of tolerances.
5. Grinding or machining finished part is sometimes the most economical procedure for obtaining close dimensional accuracy.
6. Tolerances for cold molded plastics parts are approximately double those required for hot molded plastics.

ACCURACY OF DIMENSION

COLD MOLDED	Fair
HOT MOLDED	Compression—good Injection—good Transfer—best



▲ INSERTS ▲

On figuring tolerances where inserts are involved attention must be paid to inserts' tolerances; i.e., tolerances on minor or major diameter of thread, and tolerance between that portion of insert used for its location in mold and the working portion under consideration.

DIMENSIONAL CHANGES ON AGING (Comparison)

Phenolic—heat-resisting type	1
Phenolic—low-loss type	2
Polystyrene	3
Phenolic—general purpose type	4
Phenolic—acid- and alkali-resistant	5
Phenolic—impact resistant	6
Urea	7
Cellulose acetate, cellulose acetate butyrate	8

INJECTION

Use the same tolerances for "build-up" dimensions as for dimensions parallel to mold parting line.

INJECTION MOLDED G-E MYCALEX

Minimum lateral tolerance is *plus or minus* 0.0025"/in. Tolerance on "build-up" dimension is *plus* 0.005", *minus* 0.000". Minimum taper of 1/2° per side is required on all parts.

ADDITIONAL FACTS Shrinkages and dimensional changes affecting tolerances may also be influenced by humidity, temperature of application, type of compound, etc. G.E.'s consulting engineering service will advise you on best methods of design.

ONE PLASTICS AVENUE at Pittsfield, Massachusetts, is the headquarters for five plants of the Plastics Department of General Electric Company. It signifies the location of complete plastics facilities for development, material manufacture, designing, engineering, moldmaking, molding and laminating.

REPRINTS of this advertisement may be obtained by writing Section D-3, General Electric Plastics Department, Pittsfield, Mass.

PLASTICS DEPARTMENT

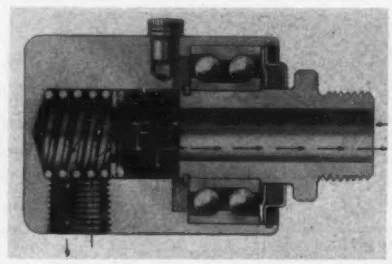
GENERAL ELECTRIC

PD-45

cages are used widely in connection with fractional horsepower motor controls, heating device controls, on dental and medical equipment, and in laboratories. In most applications, ventilated cages with perforated sides are used. Other types available are: Dustproof cages, cages to house rheostats in tandem, explosionproof cages, ventilated cages with one-half closed as a splash guard, and a laboratory type semienclosed table-top cage. Various types of terminals for the rheostat cages can be supplied.

Positive Seal Announced

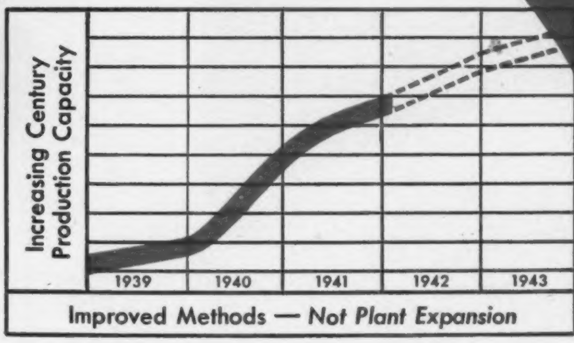
ACTING as a positive seal at the point of transmission when air or oil, under pressure or vacuum, is transmitted from a stationary to a rotating member, or from a rotating to a stationary member, the new seal announced by the Kellogg division of the American Brakeshoe & Foundry Co., 97 Humboldt street, Rochester, N. Y. can be run continuously in either direction and can be reversed



as often as necessary. This rotary seal consists of a shaft which rotates in a sealed double-row ball bearing. Seal is accomplished by a special nonmetallic seal nose, bearing against the face of the rotating shaft. Bearing surfaces, lapped for positive seal, are self-adjusting by virtue of a spiral spring which compensates for wear and maintains a constant and positive seal with minimum friction. The device is suitable for use at pressures up to 150 pounds, at temperatures up to 200 degrees Fahr. and speeds up to 2000 revolutions per minute, and is available in five sizes with oil or air passages ¼-inch to 1½ inches. The sealing device is built for long service without attention, and is designed to fill a demand for a device which would efficiently transmit air or oil, under pressure or vacuum from a stationary to a rotating member.

Variable Delivery Pump

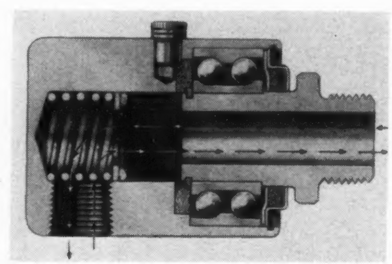
STEPLESS change from 0 to 6 gallons per minute at 5000 pounds per square inch is permitted by the new variable delivery high pressure pump, offered by Watson-Stillman Co., Roselle, N. J. The variable flow is accomplished by a new driving member trunnioned on the driveshaft; its angle being varied while the pump is running to produce a corresponding stepless change in plunger stroke from zero to full 4-inch stroke. Stroke-control shaft is extended to outside of pump casing for


Increasing Century Production Capacity
1939
1940
1941
1942
1943
Improved Methods — *Not Plant Expansion*

cages are used widely in connection with fractional horsepower motor controls, heating device controls, on dental and medical equipment, and in laboratories. In most applications, ventilated cages with perforated sides are used. Other types available are: Dustproof cages, cages to house rheostats in tandem, explosionproof cages, ventilated cages with one-half closed as a splash guard, and a laboratory type semienclosed table-top cage. Various types of terminals for the rheostat cages can be supplied.

Positive Seal Announced

ACTING as a positive seal at the point of transmission when air or oil, under pressure or vacuum, is transmitted from a stationary to a rotating member, or from a rotating to a stationary member, the new seal announced by the Kellogg division of the American Brakeshoe & Foundry Co., 97 Humboldt street, Rochester, N. Y. can be run continuously in either direction and can be reversed

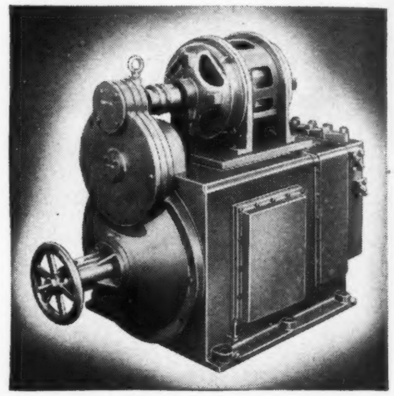


as often as necessary. This rotary seal consists of a shaft which rotates in a sealed double-row ball bearing. Seal is accomplished by a special nonmetallic seal nose, bearing against the face of the rotating shaft. Bearing surfaces, lapped for positive seal, are self-adjusting by virtue of a spiral spring which compensates for wear and maintains a constant and positive seal with minimum friction. The device is suitable for use at pressures up to 150 pounds, at temperatures up to 200 degrees Fahr. and speeds up to 2000 revolutions per minute, and is available in five sizes with oil or air passages ¼-inch to 1½ inches. The sealing device is built for long service without attention, and is designed to fill a demand for a device which would efficiently transmit air or oil, under pressure or vacuum from a stationary to a rotating member.

Variable Delivery Pump

STEPLESS change from 0 to 6 gallons per minute at 5000 pounds per square inch is permitted by the new variable delivery high pressure pump, offered by Watson-Stillman Co., Roselle, N. J. The variable flow is accomplished by a new driving member trunnioned on the driveshaft; its angle being varied while the pump is running to produce a corresponding stepless change in plunger stroke from zero to full 4-inch stroke. Stroke-control shaft is extended to outside of pump casing for

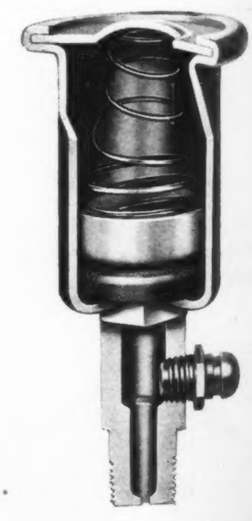
attachment either to a manual or automatic pressure control. Especially suitable on hydraulic press applications where a rapid advance must be followed by a slow movement at high pressure and for boiler feed where sudden changes in output



affecting water level are met, the pump is equipped with a 25 horsepower motor. Motor is mounted so that the entire unit is but 4 feet high and requires only 4 x 4 feet floor space. Weight is 5000 pounds. Units designed for pressures ranging from a few hundred to eight or ten thousand pounds per square inch pressure can also be built.

Reservoir Type Grease Cups

AUTOMATIC, high-pressure, reservoir type grease cups, now being offered by Bowen Products Corp., Ecorse, Mich., are recommended for use in machine tools, farm machinery, trucks, busses, cranes, mining machinery, etc. Made from heavy steel stamping, zinc plated, and assembled under pressure, this cup uses self-aligning pistons controlled by combined conical and helical springs to distribute hydraulic pressure to outer ring of cup when filled. Cup is filled with a grease gun through fitting shown on accompanying sectional illustration, which incidentally is actual size.



Grease is forced into bearings and reservoir which holds 1/3 ounce. A pressure of 3500-3800 pounds can be withstood by the cup. Cup can be filled under any available lower pressure and will operate satisfactorily in any position. Action of spring forces grease by means of pistons to bearings. All

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No oil, no wax—but a remarkable new transparentizing agent developed in the K&E laboratories—produces this truly permanent tracing paper! ALBANENE is made of 100% long fiber pure white rags—treated with *Albanite*—a new crystal clear synthetic solid, physically and chemically inert. ALBANENE will not oxidize, become brittle or lose transparency with age.

Equally important, ALBANENE has a fine hard "tooth" that takes ink or pencil beautifully and erases with ease . . . a high degree of transparency that makes tracing simple and produces strong sharp blueprints . . . extra strength to stand up under constant corrections, filing and rough handling. ALBANENE has *all* the working qualities you've always wanted—and *it will retain all these characteristics indefinitely.*

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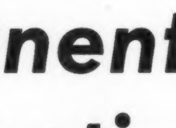
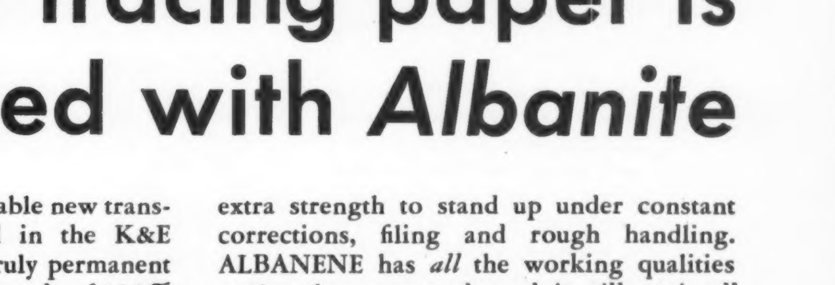
VEGETABLE OIL, chemically unstable, oxidizes easily. Papers treated with vegetable oil become rancid and brittle, turn yellow and opaque with age.



ALBANITE is a crystal-clear synthetic solid, free from oil and wax, physically and chemically inert. Because of this new stabilized transparentizing agent Albanene is unaffected by harsh climates—will not oxidize with age, become brittle or lose transparency.



foreign matter is excluded from airtight reservoir. Constant pressure applied by spring action keeps bearings lubricated as long as cup has any grease in reservoir.

Phenolic Molded Plastics

DEVELOPMENT of a new impact-resistant phenolic molding plastic, designated as phenolic resin XM-15000, has been announced by Bakelite Corp., 30 East Forty-second street, New York. This new material can be preformed on automatic tableting machines. When molded it has approximately twice the shock resistance of general-purpose phenolics, and as compared with other shock-resistant phenolic plastics its water resistance is also good.

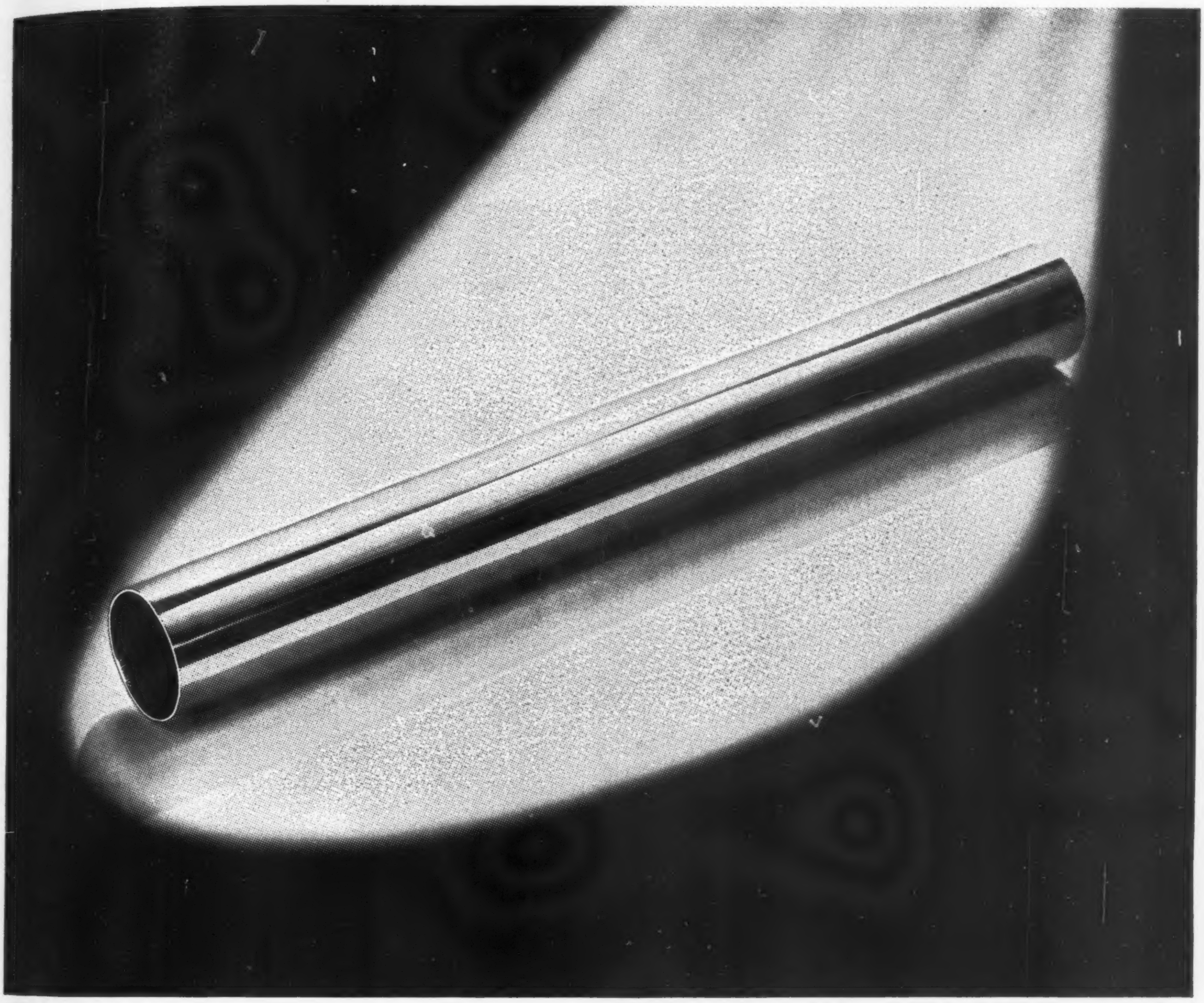
Fuel, Air-Flow, Ratio Indicator

THREE instruments in one—an air-flow, fuel-flow and ratio indicator—are incorporated in a gage recently developed by The Hays Corp., Michigan City, Ind. At a glance the exact ratio existing between gas-flow and air-flow can be determined. The spot at which the pointers cross indicates whether there is a deficiency or excess of air in proportion to the fuel and the exact percentage

of such deficiency or excess. The cross-pointer feature of the gage is adaptable also to conditions other than the relationship of fuel to air; it can be used to show the ratio existing between any two of the following functions: Flow of gas or flow of oil or other measurable fluid; pressure, draft, suction, temperature (up to 1000 degrees Fahr.), speed in revolutions per minute, or inches per minute, position, level and others.

Controls for Refrigeration

AN ENTIRELY new principle—cold anticipation—has been recently introduced by Penn Electric Switch Co., Goshen, Ind., for the refrigeration industry. This cold-control for walk-in coolers,



Presenting "GLOWELD"... THE NEW GLOBE WELDED STAINLESS STEEL TUBING

. . . Gloweld is the result of a long period of research and experiment by the Globe Steel Tubes Co., pioneer manufacturer of stainless steel tubing.

It is produced by a closely controlled electric welding process that gives it unusually smooth finish — "flash" is hardly detectable. Gloweld's light weight, high resistance to corrosion, heat and pressure, comparatively lower cost, and other advantages will find many applications for tubing in chemical and process industries, food industries, pulp and paper, oil and other industries where these factors are needed. It is already in use in aircraft construction — as hydraulic lines, and for engine parts. Available in a wide range of diameters and wall sizes, in practically all stainless steel analyses. Write for full information.

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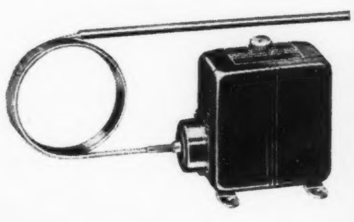
reach-in boxes, display cases and all other above-freezing applications averages box temperature and coil temperature to maintain box temperature within 1 degree of desired point without short-cycling compressor. Also provided are selective defrost (automatic coil defrosting when box is loaded with warm produce and extra cooling capacity is essential), and maintenance of proper humidity, preventing "sliming" losses and dehydration. The performance of the controls is the result of a new concept of single temperature bulb application;



one portion of the bulb being attached directly to the coil while the remainder hangs free in the air. This bulb action is influenced by a temperature drop in the coil before box temperature is affected by more than a fraction of a degree. Much smaller temperature swings occur because of the more efficient use of the coil's cooling capacity. Harmful variations in humidity are also prevented.

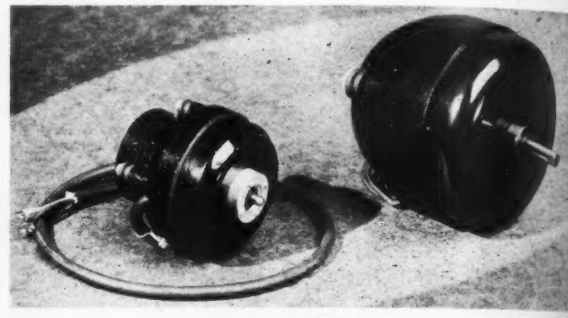
Adjustable Thermostat Offered

AN UNDERWRITER'S approved, adjustable thermostat, known as Type ASK-BB, has been introduced by George Ulanet Co., 88 East Kinney street, Newark, N. J. Assembly comprises a ½-inch bimetal element, mica insulated from a ½-inch spring. Two insulated mounting holes are also provided. The unit is capable of handling 1500 watts at 115 or 230 volts alternating current, with a maximum operating temperature of 300, 450 or 700 degrees Fahr., and can be supplied in either normally open or normally closed types. By turning a simple adjusting screw clockwise temperature is increased. The thermostat is especially suited for use on electrically-heated cabinets, rubber vulcanizing equipment, radio transmitters, etc.

Fan Motors in Three Models

UNIT-BEARING, shaded-pole fan motors for applications requiring a short, quiet, compact motor such as in commercial refrigeration apparatus, air conditioning, and ventilating systems, have been brought out by General Electric Co., Schenectady, N. Y. These motors are available in three models for 115-volt, 60-cycle operation. Frame 51AL operates with or without air over the motor at 1.5 watts, 1550 revolutions per minute, and with air over the motor at 3 watts, 1400 revolutions per minute. Frame 51EL requires air over the motor at 9 watts, 1550 revolutions per minute, and op-

erates with or without air over motor at 3.5 to 6 watts at 1550 revolutions per minute. Frame 71GL is rated 1/40 and 1/25 horsepower, 1550 revolutions per minute, air over the motor, and is for use with direct-connected propeller fans only. Uniform air gap and true bearing alignment necessary



for quiet operation is assured by both bearings and motor core being machined in one setup in a single cast member. A large oil reservoir provides operation for many years without reoiling. Free oil in reservoir is transferred to shaft of motor through wool felt, and then pumped through the bearings and into the oil return.

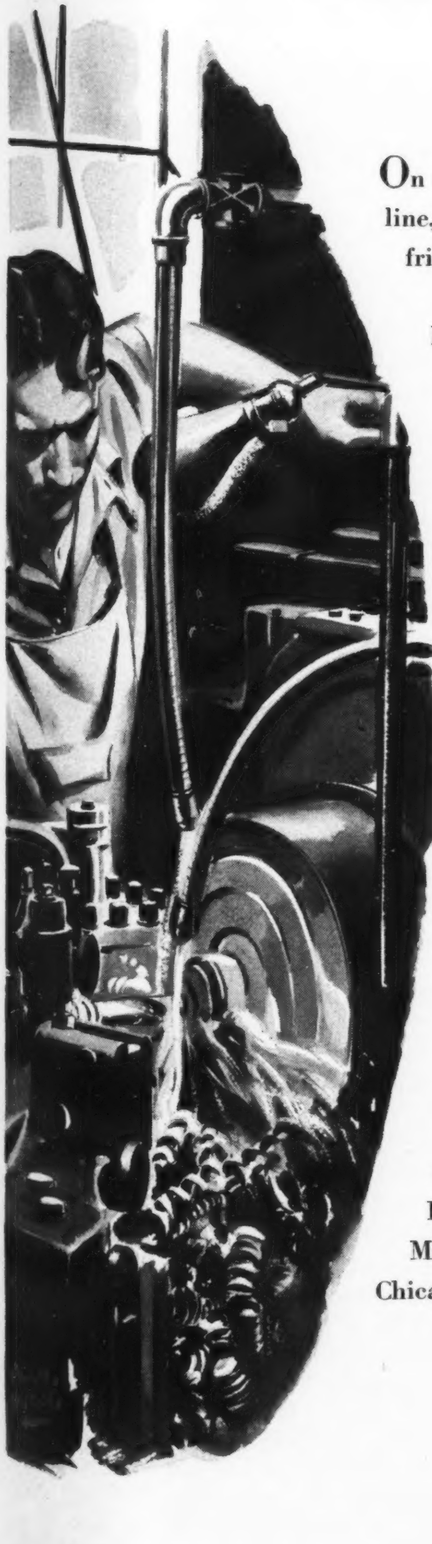
Hydraulic Coolant Pump

RECOMMENDED for use on lathes, shapers, milling, drilling and grinding machines, a new series of coolant pumps has been added to the line of Eastern Engineering Co., 45 Fox street, New Haven, Conn. In addition to their use where a steady stream of coolant or cutting oil is necessary, the pumps are also suitable for circulating non-

viscous liquids for cooling and circulating applications. Open impeller allows small chips or grit to pass without harm. Requiring no priming, this compact pump can be installed in small space. Two heights are available: Long, 19¾ inches high, weighing 35 pounds; and short, 16¾ inches high, weighing 30 pounds. The motor is ⅛ horsepower, 1725 revolutions per minute, impulsion induction,

MACHINE RUNNER and THE GUNNER

HYATTS SERVE BOTH



On the production line, as on the firing line, Hyatt Roller Bearings keep fighting friction—keep fighting for America! Correctly designed . . . precision built . . . freeing equipment from bearing wear and care . . . taking the brutal punishment of heavy loads and long hours . . . Hyatt Roller Bearings have carried on in war and peace for a half century, and will continue to serve as well in today's air, land and sea assignments.

And after industry's machines have finished their present war-time production . . . after America's guns have fired their last shots in Victory—Hyatt Roller Bearings will be serving as usual on highway and railway, in mill and factory, in farm and field—keeping things rolling quietly and economically. Hyatt Bearings Division, General Motors Corporation, Harrison, N. J., Chicago, Detroit, Pittsburgh, San Francisco.

THE 50TH YEAR OF **HYATT** ROLLER BEARINGS

semi-enclosed, for use on 110 volts, or 220 volts, 60 cycle, single-phase current. Maximum pressure of the pump is 6 pounds per square inch, with a maximum capacity of 17 gallons per minute. Pump is constructed of cast iron and so designed that there is no metal-to-metal contact below liquid level, permitting handling of nonlubricating liquids. Pump inlet above impeller is tapped for 1¼-inch standard pipe and the outlet for ½-inch standard pipe. Flange, bracket and sump mountings can be furnished for the pump.

Rustproof Coating for Metal

FOR application on diesel engine parts, electric heater meter boxes, etc., where special protection is required, a new transparent coating can be obtained from Wayne Chemical Products Co., Detroit. This corrosion-resistant, rust-preventive compound is quite elastic and is not at all brittle or sticky. It deposits but a thin coating on the metal, approximately less than one one-thousandth of an inch in thickness. Containing acetates and coal tar solvents which evaporate within a short time makes possible the handling of parts in from 3 to 5 minutes after the coating has been applied. In order to obtain a harder coating, the coated metal can be baked for about 20 minutes at a temperature of 225 degrees Fahr. This, however, does not make the coating brittle so that it will chip or crack. The coating may be applied by dipping, spraying, brushing, etc., with the dipping method being most popular inasmuch as it applies a smooth even coating.

Centrifugal Coolant Pump

MANUFACTURERS of all types of machines, especially those required for operations at full capacity under the present war program, will be interested in the increased hydraulic efficiency of coolant and circulatory pumps, produced by Brady-Penrod Inc., Muncie, Ind. Efficiency is accomplished by elevating hydraulic shock as liquid travels through pump. Design incorporates a venturi impeller inlet, constant velocity vane curvature, progressive volute and orifice conversion discharge throat. Five types of coolant and circulatory pumps, as well as those of individual design, are available. The pumps in this line can handle as much liquid with a ⅛-horsepower motor as they formerly accomplished with a ¼-horsepower motor. Two models are self-priming, permitting the pumps to be installed above the water line. Designed to eliminate wear, the pumps are suitable for use with abrasives. Pumps can be obtained with ratings established at SSU 400, 750, 1250 and 2000 which corresponds to SAE 10, 20, 30 and 40 at room temperatures. NEMA motors are used in the pumps which are built in all models for capacities from 4 gallons per minute to 100 gallons per minute, with heads up to 100.

Priorities Field Service

FOLLOWING district managers, appointed by the former Office of Production Management, serve in an advisory capacity on priorities. Chief function is to assist holders of defense contracts to obtain priority ratings on materials. Usually, they have facilities for immediate communication with the Priorities division of War Production Board in Washington. Where name of individual is not available below, requests may be addressed to district manager, Priorities Field Service, as noted below:

Alabama:
Birmingham—M. J. Lide, Phoenix Bldg.

California:
Los Angeles—G. H. Hutchins. 1151 S. Broadway.
San Francisco—Andrew L. Kerr, Federal Reserve Bank Bldg.

Colorado:
Denver—Virgil Board, U. S. National Bank Bldg.

Connecticut:
Hartford—Edwin L. Howard, 805 Main St.

Florida:
Jacksonville—George H. Andrews, Lynch Bldg.
Tampa—T. L. Hausmann, Wallace South Bldg.

Georgia:
Atlanta—John B. Reeves, 150 Hurt Bldg.

Illinois:
Chicago—Malcolm R. Macdonald, 20 North Wacker drive.

Indiana:
Indianapolis—Albert O. Evans, Circle Tower Bldg.

Iowa:
Des Moines—505 Crocker Bldg.

Kentucky:
Louisville—James T. Howington, Todd Bldg.

Louisiana:
New Orleans—John A. Bechtold, 422 Canal Bldg.

Maryland:
Baltimore—Theodore M. Chandlee, Baltimore Trust Bldg.

Massachusetts:
Boston—William P. Homans, 19 Congress St.

Michigan:
Detroit—James E. Wilson, Boulevard Bldg.

Minnesota:
Minneapolis—Willard F. Kiesner, Midland Bank Bldg.

Missouri:
Kansas City—C. H. Carr, Federal Reserve Bank Bldg.
St. Louis—L. E. Crandall, 810 Boatmen's Bank Bldg.

Montana:
Helena—Oscar A Baarson, Power Block House.

Nebraska:
Omaha—R. H. Fair, Grain Exchange Bldg.

New Jersey:
Newark—176 Sussex avenue.

New York:
Buffalo—Paul R. Smith, M. & T. Bank Bldg.
New York—Sydney Hogerton, 122 East Forty-second st.

North Carolina:
Charlotte—J. E. MacDougall, Liberty Life Bldg.

Ohio:
Cincinnati—James B. Harvey (acting), 34 East Fourth St.
Cleveland—William T. Walker, Union Commerce Bldg.
Dayton—Harold B. Doty, Third National Bank Bldg.

Oklahoma:
Oklahoma City—C. F. Aurand, 414 Key Bldg.
Tulsa—A. E. Ballin, Kennedy Bldg.

Oregon:
Portland—J. Fred Bergesch, Bedell Bldg.

Pennsylvania:
Philadelphia—Frederick W. Slack, 1617 Pennsylvania Blvd.
Pittsburgh—Charles C. Cruciger, Grant St. and Ogle Way.

Tennessee:
Knoxville—Dyer Butterfield, Goode Bldg.
Memphis—J. S. Bronson, Sterrick Bldg.
Nashville—George S. Gillen, 1015 Stohlman Bldg.

Texas:
Dallas—James B. Crockett, Wood and Akard Sts.
El Paso—R. C. Stryker, El Paso National Bank Bldg.
Houston—George L. Noble Jr., Federal Reserve Bank Bldg.
San Antonio—Carl L. Pool, 415 West French Place.

Utah:
Salt Lake City—Ralph E. Bristol, Utah Oil Bldg.

Virginia:
Richmond—Fred P. Wilmer, 10 South Fifth St.

Washington:
Seattle—William D. Shannon, Stuart St.

Wisconsin:
Milwaukee—Frank J. Tharinger, First Wisconsin National Bank Bldg.

ASSETS to a BOOKCASE

Mechanical Properties of Materials and Design

By Joseph Marin, Professor of Mechanics, Pennsylvania State College; published by McGraw-Hill Book Co., New York; 273 *pages,* 6 *by* 9 *inches, clothbound, available through* MACHINE DESIGN *for* $3.50 *postpaid.*

Current material shortages combined with modern developments in engineering design tending toward the use of increased speeds, lightweight construction, and higher operating temperatures, make this an important reference book for the engineer. The object of the book is to furnish a survey of the mechanical properties of engineering materials and to show how a consideration of these properties modifies usual design procedure. To this end simple and combined static, fatigue, impact, and creep stresses are considered in their relation to service conditions, part shape, etc.

Testing technique and methods are only briefly discussed, emphasis being placed on the interpretation of test results for the purpose of determining working stress values or for the selection of the material to be used. As examples, designs of specific machine and structural members are given to demonstrate how a consideration of the more recent theories influence the required dimensions of these members. The book is illustrated with working stress and design charts intended to simplify the designer's use of this material. Readers of MACHINE DESIGN, familiar with Professor Marin's current contributions of articles on stress determination, will appreciate in his book the same lucidity and thoroughness so notable in the articles.

□ □ □

Basic Units in Mechanical Drawing

By Randolph Phillip Hoelscher and Arthur Beverley Mays, University of Illinois; volume I, second edition, published by John Wiley & Sons Inc., New York; 305 *pages,* 6 *by* 9 *inches, clothbound, available through* MACHINE DESIGN *for* $1.60 *postpaid.*

For exhaustive detail covering the fundamentals of mechanical drawing this book is unsurpassed. Each of the 34 individual units is discussed in five parts: Purpose, what you should know, how to do, questions, and problems. It is thus ideal both as a text for beginners in mechanical drawing as well as a ready reference to fundamental drawing principles for the drafting room and engineering department.

As an example of the detail in which each sub-

ject is discussed, in the section devoted to "lettering," each letter is considered separately. Not only is the proper direction of pen or pencil strokes for each element of the letter indicated, but also the sequence in which each is drawn.

□ □ □

Industrial Plastics

By Herbert R. Simonds; published by the Pitman Publishing Corp., New York; 385 *pages,* 6 *by* 9 *inches, clothbound, available through* MACHINE DESIGN *for* $4.50 *postpaid.*

As a fundamental reference to the comparatively new field of plastics as an engineering material this book affords an excellent general survey of the entire industry. Engineers interested in the application of plastics in their design will find such basic information invaluable.

Following a brief history of the development and extent of the plastics industry, the basic constitutents of commercial materials are discussed including resins, fillers, pigments, catalysts, and their various sources. This treatment is then extended logically to a consideration of the chemistry of the various types of plastic materials.

Applicability of the different molding techniques such as pressure molding, injection molding, cold molding, etc., as well as several methods of plastic fabrication including laminating, bonding, machining, and finishing, provide a proper introduction to a discussion of plant and equipment.

A thought-provoking chapter and one which gives evidence of the progressive treatment of the subject characteristic of the book is that devoted to the future of plastics. In this chapter typical research problems are indicated as well as the position of plastics in our wartime economy.

□ □ □

Airframes

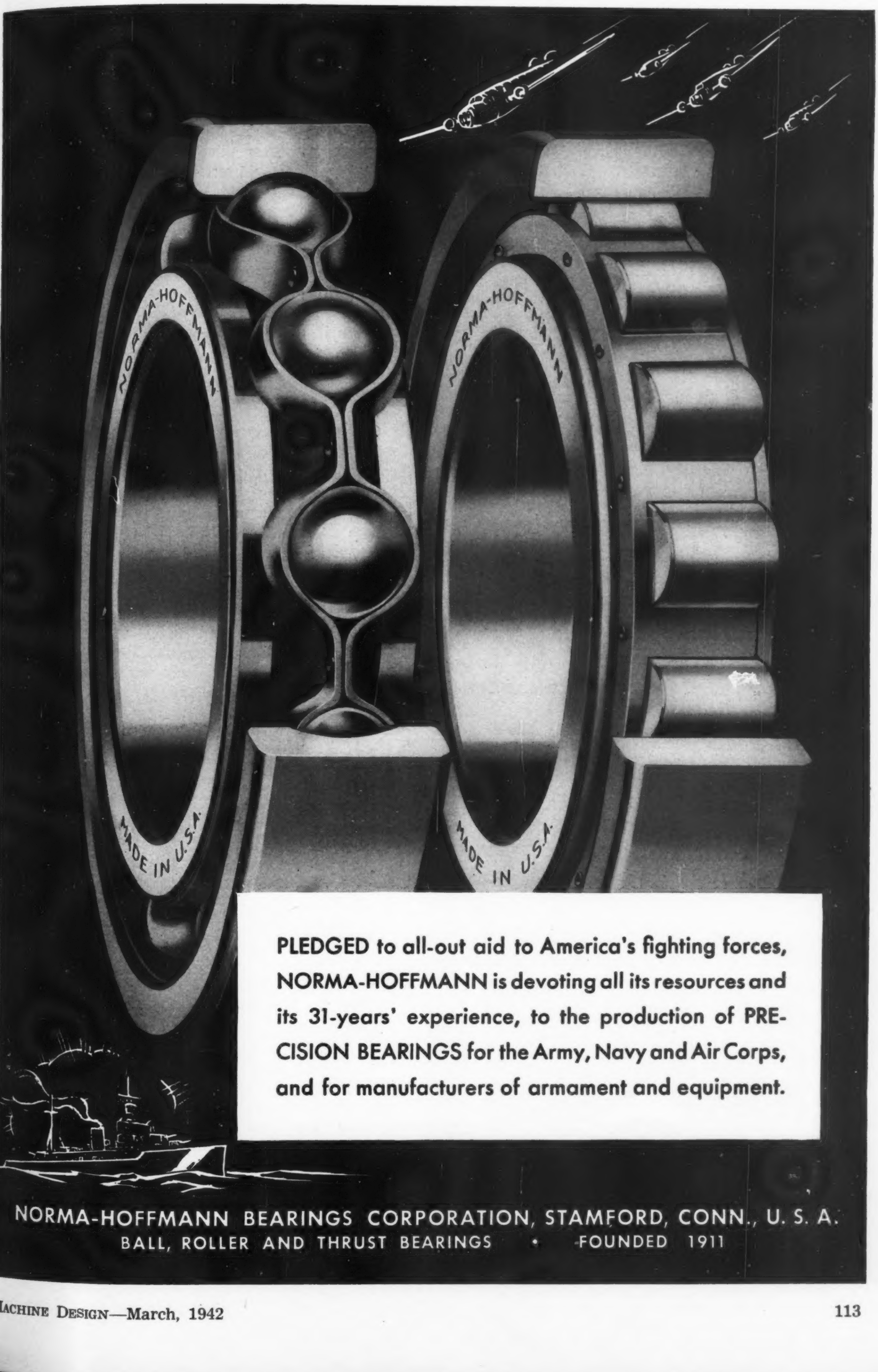
Edited by E. Molloy; Part III, published by The Chemical Publishing Co., New York; 132 *pages,* 5½ *by* 8½ *inches, clothbound, available through* MACHINE DESIGN *for* $2.50 *postpaid.*

For engineers interested in the structural design of aircraft this book will be of considerable value. The discussion is devoted to the design features of the Bristol Blenheim, Taylorcraft, Cunningham Hall, and Douglas airplanes, with particular attention to the design of the fuselage and wing assemblies including such control systems as the rudder and elevator. The book is profusely illustrated with both exterior and interior photographs as well as drawings and schematic diagrams of the control circuits and the location of the various integral elements of the ship. Attention is also paid to a number of different methods of fabrication and their effect upon the structural design.

MEN Of Machines

AFTER thirteen years as research engineer with Bell Telephone Laboratories Inc., New York, Robert M. Kalb has become assistant chief engineer of Kellogg Switchboard & Supply Co., Chicago. Born at Fostoria, O., Mr. Kalb graduated from Ohio State university and from Polytechnic Institute of Brooklyn in electrical engineering, and from Ohio State and Columbia universities in mathematics and physics. After a brief interval during which he taught in the electrical engineering laboratory of Ohio State, he joined the Bell Telephone Laboratories as research engineer. While there he was engaged in transmission development problems involving submarine cables and repeater lines. He also carried on extensive investigations in ferromagnetics and in nonlinear circuits: and more recently, was concerned with switching and relay developments.

BEGINNING his career as an errand and blueprint boy in the saw-mill engineering department of Allis-Chalmers Mfg. Co. because family circumstances did not permit completing his schooling, Walter Geist is today vice president of this company and also a director of York Ice Machinery Corp. He advanced to tracer and draftsman, and then progressed through vari-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PLEDGED to all-out aid to America's fighting forces, NORMA-HOFFMANN is devoting all its resources and its 31-years' experience, to the production of PRECISION BEARINGS for the Army, Navy and Air Corps, and for manufacturers of armament and equipment.
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ous positions and departments, learning various operations of the company. As design engineer in the flour mill department he became interested in power transmission which led to his development of the multiple V-belt drive. As a result of Mr. Geist's research and original work in the field of power transmission, he was awarded the 1940 plaque of a modern pioneer by Dr. Karl T. Compton of the Massachusetts Institute of Technology. After obtaining early engineering experience he became associated with sales engineering, and was appointed assistant manager of the milling department in 1928. Five years' later he became general representative of the company in charge of all personnel in the company's district offices. In 1939 he was elected vice president of Allis-Chalmers which position he will continue to fill in addition to his most recent appointment as a director of York Ice Machinery Corp.

♦

George Tharratt is the new chief engineer of Adel Precision Products Corp., in accordance with a recent announcement made by H. Ray Ellinwood, president of the Burbank aircraft accessory concern. Formerly assistant chief engineer at Vultee Aircraft, Fred Herzer has been made vice president in charge of production at the Adel company.

♦

H. T. Florence, connected for twenty years with The Cleveland Crane & Engineering Co., Wickliffe, O., in various capacities including engineering, has been appointed vice president.

NOTED designer of military and civilian motor vehicles for specialized off-the-road services, A. W. Herrington has been elected president of the Society of Automotive Engineers for 1942. He is president of the Marmon-Herrington Co. Inc., Indianapolis.

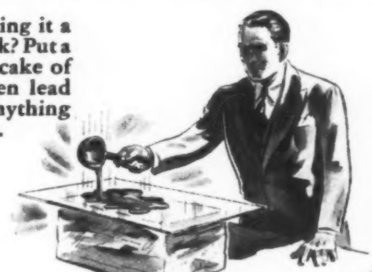
As captain of motor transport in World War I, he became interested in the design of off-the-road motor equipment more suitable for military and unusual civilian services than any then available. During 1921 to 1931, in association with various automobile companies, the U. S. Army and the Marine Corps as consulting engineers, he developed numerous specialty truck designs. At the end of this time the Marmon-Herrington Co. Inc. was formed, based on Mr. Herrington's conviction that

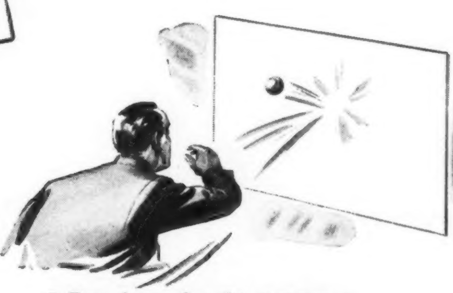
Wanted...

TOUGHER JOBS FOR GLASS WITH A TEMPER!

1 Here's a sheet of L·O·F Tuf-Flex Heat Tempered Plate Glass. By looks you'd swear it was just a pane of the clearest, polished plate glass.

2 Well, how about giving it a punishing thermal shock? Put a sheet of Tuf-Flex on a cake of ice and pour hot molten lead over its top-side. If anything cracks it will be the ice.





3 But, just give its temper a test. Borrow sonny's baseball and wing your fastest one smack into its middle. Try again. Tuf-Flex won't even shudder.

4 Maybe you'd like a try at supporting the family on Tuf-Flex. Don't worry, it won't let you down, for we've seen a sheet only ¾-inch thick support the weight of a full-grown bull elephant.

L·O·F TUF-FLEX Solves Demands For A Glass That Can Take Severe Punishment

Through a special heat tempering process, L·O·F transforms fine plate glass into a glass that is three to seven times stronger, three times more resistant to thermal shock, and many times more flexible. It's called TUF-FLEX Heat Tempered Plate Glass.

Here's a glass that has been subjected to the most severe tests with the most amazing results. It has been jarred by constant vibration, dropped from unusual heights, tortured by temperature extremes, twisted through angles of 20 degrees, all without failure.

The uses of Tuf-Flex are practically unlimited. It takes the pounding of the sea as porthole glass. It serves as protective shields on machine tools. And because of its high resistance to thermal shock it is proving most successful as lenses in giant searchlights and as glass windows for oven doors.

On your own Main Street, Tuf-Flex is probably serving many merchants as modern all-glass doors. It also serves in display windows and cases where extra strength and protection are needed. An added safety feature is the fact that when Tuf-Flex glass is fractured, it disintegrates into small, relatively harmless crystals.

Quite likely Tuf-Flex may prove the answer to a problem in your business. Our engineers will gladly discuss it with you. Libbey·Owens·Ford Glass Company, 1319 Nicholas Building, Toledo, Ohio.

IF YOU HAVE A RAW MATERIAL PROBLEM...

IF YOU ARE SEEKING A SATISFACTORY REPLACEMENT MATERIAL...

BE SURE TO INVESTIGATE...

FLAT GLASS

New developments, New L·O·F glass products, now substantially broaden the usefulness of FLAT GLASS

Flat Glass is today prepared to serve in many new ways. L·O·F research has perfected many new types of glass with thermal, acoustical, structural, lighting, decorative and other qualities which may prove a *better* answer to your material problem. May we help you?

LIBBEY·OWENS·FORD
Quality *Flat Glass* Products

no hauling or transportation job was too tough to solve with hard-headed engineering. Through his company considerable military equipment has been provided to Great Britain, The Netherlands East Indies, Greece, China, Iraq, Egypt, South America, Canada and the United States. Twelve-wheel, 65-ton trucks, designed by him, have been used in the Near East, and other equipment in logging camps in the Northwest. Special busses made under his supervision have also made possible passenger routes over the deserts in the Near East. Mr. Herrington is an author of a number of important technical papers, and has been active in technical and administrative affairs of the society for many years.

♦

O. E. Mount of American Steel Foundries, Chicago, has been made president of the Steel Founders' Society of America, Cleveland. L. C. Wilson of the Reading Steel Casting division of American Chain & Cable Co., Reading, Pa., is vice president of the society.

♦

H. T. Woolson, executive engineer, Chrysler Corp., was recently re-elected vice-chairman of the Engineers' Council for Professional development.

♦

Otto R. Schoenrock has recently been appointed chief engineer for the J. I. Case Co., and David P. Davies, vice president, has been named consulting engineer for all the company's factories.

♦

Dr. Jesse B. Hobson, in charge of application engineering on electric power equipment, Westinghouse Electric & Mfg. Co. in the northwestern district, has been appointed director of the electrical engineering department, Illinois Institute of Technology.

♦

John H. Ashbaugh has been made manager of manufacturing and engineering of the merchandising division, Westinghouse Electric & Mfg. Co., East Pittsburgh. He has been acting manager of the two departments since January 1941. Starting with the company as a student engineer, he was transferred to the merchandising division as assistant manager of engineering of Springfield, O. works in 1931. In less than a year he was named manager of engineering.

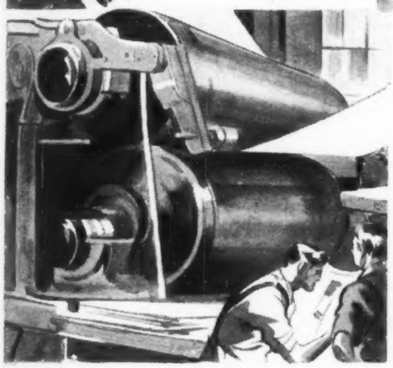
♦

J. W. McNairy, who has been associated in various engineering and manufacturing capacities with General Electric Co. for 24 years, has been appointed assistant manager of the Bridgeport works of the company. Previous to this appointment Mr. McNairy was assistant to the manager in charge of engineering.

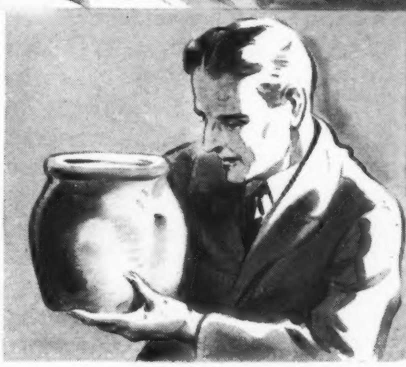
♦

M. J. Healey has been appointed to the farm equipment unit, machinery section, Office of Price Administration. Mr. Healey, a farm machinery expert of Kansas City, Mo., was a director of Deere & Co. and John Deere Plow Co.

Say! Is there anything it can't pump?

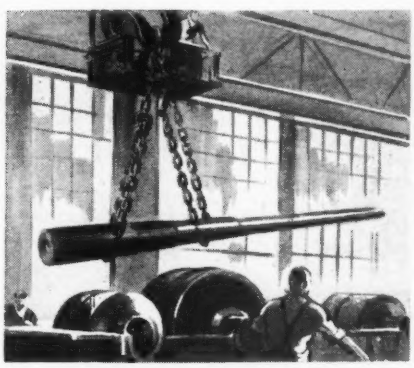


1. Sure, but there are very few tough jobs that the R & M Moyno Pump *can't* lick. One of the largest paper mills, for example, uses 16 of these pumps to handle paper coating, with more uniform feed to coating rolls and with tremendous savings in time and operating costs.

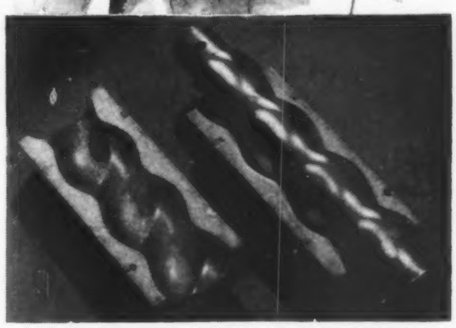


2. In dozens of ceramic plants R & M Moyno Pumps are handling highly abrasive slip and gritty enamel coating. The pumps are standing up under service with remarkable wear resistance. Uniform, gentle action eliminates air bubbles, reduces rejects and improves product quality.

3. Even in handling water the R & M Moyno proves superior. It's standard equipment on a famous car washer. It's the integral unit of a deep-well water pump that's furnishing economical, dependable water supplies for hundreds of municipalities, army camps and industrial plants.



4. A large lathe manufacturer greatly increased the boring speed of a gun lathe by using R & M Moyno Pumps to high-pressure coolant. The pump delivers the coolant with continuous force sufficient to sluice chips away. A special folder on coolant pumps is yours for the asking.



5. The operating principle of the R & M Moyno Pump is the secret of its pumping efficiency. A single-threaded, helical rotor revolves within a double-threaded, helical stator, like a screw turning in a flexible bearing. Action is like that of a piston pushing fluid through an endless cylinder. The R & M Moyno is self-priming, positive in displacement, light and compact. It is flexible in design and adaptable to all types of pumping applications.

INVESTIGATE the R & M MOYNO NOW!

• Mail this coupon today for folder and complete details. Please specify type of job you expect pump to handle.

ROBBINS & MYERS, Inc., Moyno Pump Division, Springfield, Ohio

Please send me information about the R & M Moyno Pump.

Name ______________________

Firm Name ______________________

Address ______________________

City ______________ *State* ______________

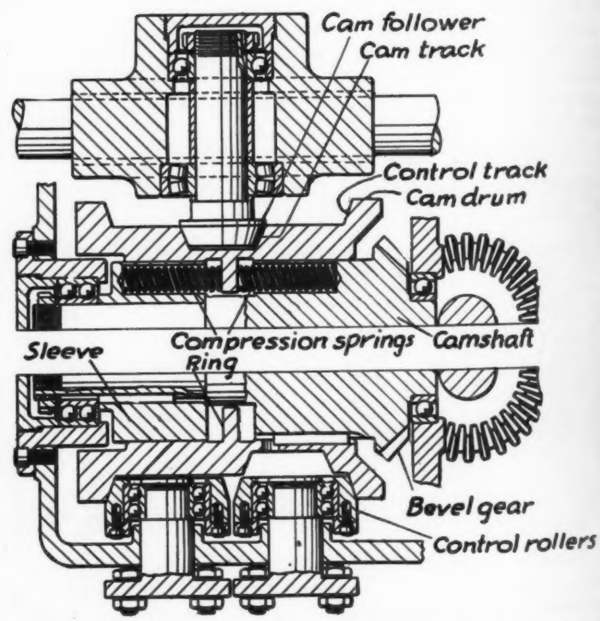
Pump will handle ______________________

Noteworthy PATENTS

Absorbs Shock Loads

CHANGES in the direction of displacement of the cam follower of drum-type cylindrical cams may impose excessive momentary loads on both the follower and the cam. When resilient shock-absorbing elements are used to reduce the effect of these overloads they deflect under the force of the working stroke of the cam follower, detracting from its operating precision. In a patent assigned to the Weskenson Corp., shock absorbing means are employed in conjunction with an auxiliary control track on the drum cam surface which prevents undesirable axial motion of the follower during its normal working and return strokes.

Shown in the upper part of the illustration is the cam follower mechanism designed to slide under



Control track and rollers permit shock absorption at desired points of cam cycle and maintain precision movement elsewhere

the impetus of the cam either to the right or left on the fixed follower shaft. The camshaft is driven through an integral bevel gear and has keyed to it the drum cam. To facilitate assembly, the left end of the camshaft consists of a removable sleeve which is keyed to the shaft extension. Inserted in recesses in the periphery of the camshaft and sleeve are pairs of helical compressions springs which bear

in equilibrium against an inwardly extending annular ring integral with the cam.

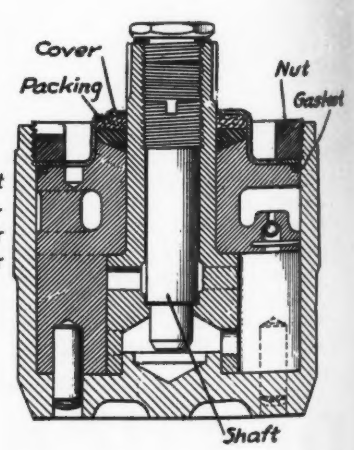
In the illustrated position the follower is in its working stroke. By reason of the interaction of the control roller and the control track no axial movement of the cam is possible. The springs are thus inoperative. The control roller and the control track are shown in the lower part of the illustration. As the follower approaches a point at which the direction of displacement is to be reversed the walls of the control track are displaced away from each other. Thus the control rollers are no longer in contact with the walls of the track. Hence, if a shock load is imposed on the cam track either by reason of the momentum of the follower mechanism or the sudden reversal of motion the compression springs will absorb the shock by permitting slight axial motion of the drum cam.

It is, of course, possible by properly forming the tapered wall of the control track to make the compression springs operable over as much or as little of the cam cycle as desired. For example, such control can be exercised over the working stroke alone or over both the working and the return stroke, permitting shock-absorbing action to take place only at the point at which the direction of motion is reversed.

Stamping Effects Cost Decrease

IMPROVEMENT in operation, reduced cost, and facilitation of assembly and disassembly, are often mutually inconsistent features in the design of a machine. However, in a patent assigned to the Houde Engineering Corp., these three attributes have been achieved simply and ingeniously. A sheet metal stamping constitutes the heart of this improvement.

Developed to provide the sealing means for a conventional rotary-type, hydraulic shock absorber, the single stamped part serves to maintain a tight



Spring action of sheet metal cup compensates for slight wear of the shock absorber shaft packing

gasket joint around the periphery of the housing and at the same time maintain constant pressure on the packed joint surrounding the shock absorber shaft. The stamped part has a cylindrical body

with an inwardly extending upper flange and an outwardly extending lower flange. The periphery of the lower flange is clamped against the gasket by means of a nut which is slotted or drilled to accommodate a spanner wrench. This nut provides the sole fastening means for the entire assembly of the shock absorber. If it is removed the mechanism may be withdrawn from the housing.

After all working parts of the unit are installed in the housing the packing material is placed around the shaft. The sheet metal cup is then placed over the packing material and the nut tightened. Spring qualities inherent in the cup then act to maintain adequate pressure against the packing even though an appreciable amount of wear may be experienced. Thus the important requirement of preventing the leakage of fluid from a hydraulic shock absorber is accomplished along with a substantial decrease in the total cost of the unit, as well as the considerable simplification of assembly and disassembly for maintenance.

Controls Speed Without Hunting

COMBINING the function of a fuel pump and a speed-controlling governor, the illustrated compact design is intended to maintain diesel engines running at constant speed. One outstanding advantage of this device, the patent for which is assigned to the Eisemann Magneto Corp., is the fact that combining the governor with the fuel pump in one housing greatly increases the difficulty of unauthorized tampering with the governor setting.

Consisting of a number of cylinders arranged in a circle with axes parallel, the pumping part of the unit is driven from an inclined cam or wabble-plate. Follower rollers attached to the lower ends of the pistons are spring-loaded to maintain constant and intimate contact with the cam surface.

The cam itself is mounted in a radial-thrust type ball bearing driven by a driveshaft rotated from any convenient take-off point on the engine. On the descending stroke, fuel is drawn from the tank or reservoir by the piston. After flowing through the inlet ports into the chamber above the piston it is then on the ascending stroke forced under pressure through the fuel line to the engine. This flow continues until the by-pass groove on the piston is in alignment with the vent passage in the housing. Pressure above the piston is thereby relieved and fuel flow stopped.

Linkage Actuates Valve

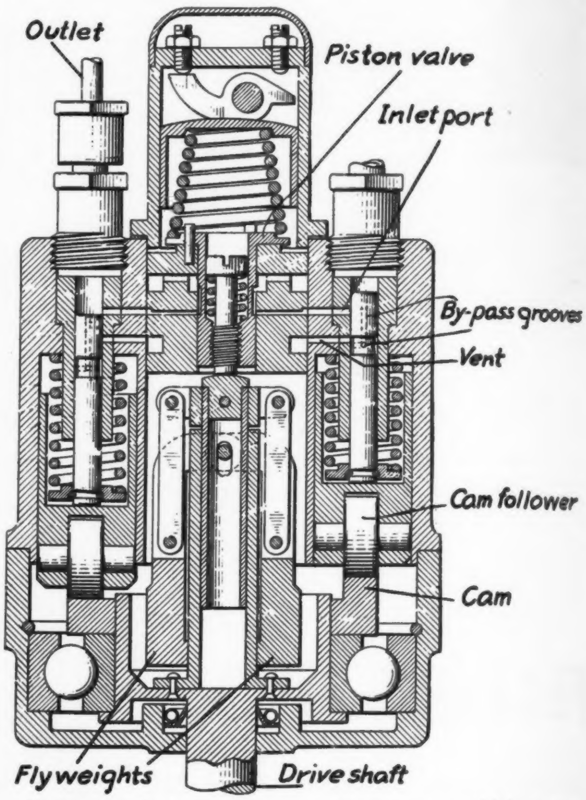
Also driven by the driveshaft are a pair of flyweights attached to a shaft extension. These flyweights are connected by an appropriate linkage which actuates a piston valve that controls the flow of fuel through the inlet ports.

As the engine speed tends to increase the piston valve is raised against the conical helical spring. In this manner the circumferential groove around


THE ANSWER
TO MANY A
DESIGNER'S
PROBLEM

the piston valve is moved out of registration with the inlet port, thereby stopping the fuel flow. Conversely, as the engine speed tends to decrease, the piston valve is lowered by the flyweights, again re-establishing fluid flow through the inlet port.

As indicated there are two separate points of adjustment. The first is provided by the spring-loaded adjustment screw tapped into the piston



Spring-loaded rollers running on wabble-plate operate pistons of fuel pump. Flyweights control effective displacement of cylinders by venting at a portion or full stroke

valve. By backing-out this screw it is evident that the piston valve is permitted to drop; thus the speed at which the engine operates is increased. The second adjustment is by means of the cam which controls the pressure of the conical helical spring in the upper part of the housing. Increasing the compression of this spring reduces the sensitivity of the governor. Apparently, an optimum setting may be arrived at which will obviate any tendency of the governor to hunt and yet be able to maintain the speed of the engine substantially constant.

Not the least remarkable of the features of this device is the manner in which assembly problems were overcome in designing all the parts into proper working relationship in one body or casing. As is evident from the illustration, the casing is separable into two parts. Cylinders, piston valve and wabble-plate followers are in the upper; wabble-plate, bearing assembly and driveshaft are in the lower. Flyweights, followers, springs and pistons all can be lifted out when the body sections are separated.

Facing the Facts

(*Continued from Page* 46)

fications have been changed to reduce or eliminate the use of such critical materials as aluminum, chlorine, chromium, copper, and cork—to mention only a few. The Army Quartermaster Corps was able in a period of four months to reduce its requirements of copper for 1942 from 150 million pounds to 40 million pounds.

Much can be done without any change in design, merely through the simplification of line. Many concerns have a much wider variety of items than the consumer economy requires. Large savings can often be made simply by dropping from a line of goods those items which require the largest amounts of critical materials per unit produced. A case in point is that of the refrigerator industry, which in the past has had deluxe, standard, and economy lines. Eighty per cent of its business is done on 20 per cent of this industry's complete line. This industry has already agreed to concentrate on the production of the economy line, thus permitting the production of equally serviceable but less decorative units with the same amount of material.

How to Avoid Waste

A final method of conserving materials without changing specifications is through avoidance of manufacturing waste. This can be done in two ways—by reducing the percentage of rejections of finished parts, and by better recovery of scrap materials within the manufacturing plants which use them, or better still by making less scrap.

It is hard to overemphasize the importance of the work which industry can do in all of these fields. But at the same time it is important that we do not let our emphasis on this point blind us to the situation which we are facing. Even wth the utmost that can be done in the way of making more out of less, the unfortunate fact remains that these material shortages are going to be more acute.

That means, for one thing, that the supply of all of these materials must be increased wherever and whenever it is possible to do so. An honest and effective effort has been and is being made in that direction; in most cases the government has done the best that could be done to make greater supplies of the critical materials available.

This is a good time for the adoption of what we might call an engineering attitude by industry in regard to these expansion possibilities. By that is meant that where it is a question of expanding the production of a critical material, the problem should be approached first from the viewpoint: What is the maximum production which it is physically possible to achieve? Taking that viewpoint is the only way to get a valid standard against which the expansion program can be measured. After that viewpoint

there's a lot of difference in cylinders . .

Cylinders must be built not only to resist wear but to exert the maximum amount of power that a given bore cylinder operating at a given pressure per square inch—can theoretically exert. This gets all there is out of the compressed air or hydraulic pressure supplied.

To do this, T-J Cylinders use low friction factor leathers that at the same time provide an effective seal. T-J Air Cylinders when used at 80 lbs. pressure p.s.i. and T-J Hydraulic Cylinders when used at from 500 to 1500 lbs. pressure p.s.i. perform at an average mechanical efficiency of 95%. We will gladly go over the construction features of these cylinders with you. The Tomkins-Johnson Co., 618 N. Mechanic St., Jackson, Michigan.

T-J

Hyd. Cyl. Style HH2 shown

this is a **TOMKINS-JOHNSON** *product*

IF YOU'RE TROUBLED BY PRIORITIES OR PROBLEMS IN PROTECTING IRON & STEEL

the JETAL process

PATENTED

JETAL

(THE BLACK OXIDE FINISH)

is the answer

JETAL can be substituted for nickel, zinc, cadmium and tin plating.

JETAL assures 100% increase in production. Requires no skill, no elaborate equipment, no electrical current.

JETAL gives from 50% to 70% more abrasion and wear resistance—as high as 230%, by changes in procedure.

JETAL, with proper protective oils or lacquers, offers high salt spray resistance.

JETAL saves you 30% in price . . and goes farther.

JETAL, as a base for lacquers, enamels and japan shows superior salt spray resistance, improved bonding and prevents spreading of corrosion under the film.

Immediate delivery—any quantity.

Send samples for JETALizing *without charge. Consultation service without obligation.*

ALROSE CHEMICAL COMPANY

Providence, R. I. *Tel. Williams 3000*

What types of backing steel are available in Jessop *Silver-Ply** Stainless-Clad Steel?

The second in a series of advertisements which describe the physical characteristics of Jessop SILVER-PLY Stainless-Clad Steel for the guidance of designers and fabricators of processing equipment.

Jacketed reactor with specially designed agitator and drive for synthetic rubber products. Shell made from Jessop SILVER-PLY Stainless-Clad Steel by the Patterson Foundry & Machine Co., East Liverpool, Ohio.

° While the type and degree of stainless-steel cladding is the most important factor in selecting a stainless-clad steel, the type of backing steel should also be given consideration. Since most of the sheet or plate is backing steel (usually 80%), the type of backing steel selected will influence the physical properties of the composite sheet or plate. Sheets and plates of Jessop SILVER-PLY Stainless-Clad Steel are customarily supplied with either of two types of backing steel. Their chemical compositions and physical properties are as follows:

CHEMICAL COMPOSITIONS

Type	Carbon (Max.) Percent	Manganese (Max.) Percent	Sulphur (Max.) Percent	Phosphorus (Max.) Percent	Silicon Percent	Molybdenum Percent
A	0.25	0.90	0.04	0.04	....	....
B	.20	.90	.04	.04	.15-.40	.40-.60

PHYSICAL PROPERTIES

Type	Tensile Strength Lbs. Per Sq. In. (Min.)	Elongation (Min.)	Yield Point (Min.)	Red. of Area (Min.)
A	55,000	25%	30,000	35%
B	65,000	20%	35,000	30%

Type A backing steel is supplied on Jessop SILVER-PLY Stainless-Clad Steel at the base price for the various types and degrees of cladding listed in our latest price list. Type B backing steel is supplied at 3½ cents per pound extra. The higher cost of Type B steel is justified when the higher physical properties are required, as, for example, in certain types of pressure vessels. Other types, to special specifications may be made available. Direct inquiries to the General Office.

Use of Jessop SILVER-PLY Stainless-Clad Steel in stainless equipment not only saves up to 45% in material costs as compared to solid stainless but also offers an effective means of conserving strategic alloying elements. If you are not familiar with SILVER-PLY write today for our 24-page descriptive booklet and our new price list.

JESSOP STEEL CO. MADE IN AMERICA FINE JESSOP STEELS WASHINGTON, PA.

*Produced under U. S. Pat. Nos. 1,997,538 and 2,044,742

JESSOP STEEL COMPANY

General Offices and Works
WASHINGTON, PENNA., U. S. A.

JESSOP

JESSOP STEELS FOR AMERICA AND HER ALLIES

CARBON . HIGH SPEED . SPECIAL ALLOY . STAINLESS . COMPOSITE STEELS

is taken, all of the other considerations can be reviewed and given their proper weight; but during this emergency we must shape our approach to the problem by the engineering standard rather than by the ordinary standard of profit and loss.

The fact that we are not going to be able to get completely around these shortages means an over-all change in our national productive system for the duration of the emergency. We must produce an unparalleled quantity of war goods; we also face the continued demand for civilian goods. The two demands together far outrun our total productive capacity. That will continue to be true even after we have made all of the savings that can be made. Consequently we face the necessity of concentrating on the more essential kinds of production, whether they be civilian or military. We may be able to have both guns and butter, but we can't have both guns and gadgets.

The period just ahead is going to be a trying one for all of us. Yet it need not be discouraging. A great many problems must be solved during the near future—none are beyond our ability to solve if we make a united effort. The great gains which this nation has made in the past were all made the hard way. We can take the hard way this time and get through without faltering—and when it is all over, we shall find that we have truly made, in the interest of all our people, one of the greatest gains in our history. Industry *will not be weighed* in the balance and found wanting.

Selecting Screens

(*Concluded from Page* 65)

creased through supporting and reducing secondary vibrations in this manner. Operation is aided by distributing the material more evenly over the surface to utilize the entire area more effectively. If material does not reach the sides of the screen, a higher crown is indicated.

Electrically formed screens, although relatively expensive, have possibilities especially where extremely fine mesh is involved. Formed by a process resembling that for an engraver's electrotype, screens are capable of continuous production and are of integral construction like perforated screens. They can be produced in fine meshes beyond the limits of mechanical perforations. Gaskets may be produced as a part of a screen and any desired shape may be initially formed by this method. *Fig.* 10 shows a strainer of electrically formed cloth.

Co-operation of the following companies in supplying information and illustrations is gratefully acknowledged: Allis-Chalmers; Buffalo Wire Works; The Cambridge Wire Cloth Co., *Fig.* 3; Champion Paper & Fiber Co., *Fig.* 1; The Harrington & King Perforating Co.; Hendrick Mfg. Co.; The Jeffrey Mfg. Co.; C. O. Jelliff Mfg. Co., *Fig.* 10; Link Belt Co.; Michigan Wire Cloth Co., *Fig.* 2; Newark Wire Cloth Co.; Productive Equipment Corp.; Robins Conveying Belt Co.; Screen Equipment Co., *Figs.* 6, 7 and 8; T. Shriver & Co., *Fig.* 5; W. S. Tyler Co., *Figs.* 4 and 9; W. Richard Witte & Co.

Mobility Method for Linear Vibrations

(*Concluded from Page* 60)

pendent on the frequency. Compliance l of the spring (beam) is $L^3/48EI$ where L is the span, E the modulus of elasticity, and I the moment of inertia of the beam section.

The structure diagram is similar to that shown in *Fig.* 1*a* with the exception that F is now $m\omega^2d$. Letting s_B equal the displacement amplitude of the mass,

$$Z_B = \frac{j}{\frac{1}{\omega l} - \omega m}$$

$$s_B = \frac{v}{j\omega} = \frac{m\omega^2 dj}{j\omega}\left[\frac{1}{\frac{1}{\omega l} - \omega m}\right]$$

$$s_B = m\omega^2 ld\left[\frac{1}{1-\omega^2 lm}\right] \qquad (14)$$

Equation 14 shows that the displacement of the mass becomes infinite when the denominator is zero. Let $\omega = \omega_c$ at this resonant condition. Critical speed then is

$$\omega_c = \sqrt{\frac{1}{lm}} \qquad (15)$$

The resonance diagram is shown in *Fig.* 6.

Usefulness and convenience of the mobility method is illustrated in the above examples. Numerous other illustrations could be cited. The analysis is direct, no differential equations being required. Numerical computations follow immediately after the schematic diagram is drawn. Of course, the mobility method is limited to the assumptions stated. These assumptions, however, are reasonable for a good number of important, practical cases.

Nomenclature

- $j = \sqrt{-1}$
- F = force, pounds
- s = linear displacement, inches
- v = Linear velocity, inches per pound
- a = linear acceleration, inches per second per second
- m = mass of an element, weight (pounds)/g
- g = gravitational acceleration, 386 inches per second per second
- f = frequency of vibration, cycles per second, $\omega/2\pi$
- ω = circular or angular frequency, radians per second, $2\pi f$
- t = time, eseconds
- l = compliance of a spring, displacement produced across spring by unit force through spring, reciprocal of spring constant, inches per pound
- $Z = v/F$ = mobility of an element or a group of elements, a complex number, inches per second per pound
- r = responsiveness of a resistor, linear velocity per unit frictional force, same units as mobility.

Business and Sales Briefs

OPENING of a new factory branch at 1215 Capitol, Houston, Tex., has been announced by the Frederick Post Co., Chicago. A complete line of blueprint and kindred sensitized products, drafting and engineering materials will be carried to facilitate prompt service and quick delivery.

♦

Ampco Metal Inc., Milwaukee, has transferred J. E. Heuser to its Cincinnati office located at 30 West Pearl street, to assist J. E. Cook of that division. Another appointment by the company is that of J. P. Henry as its New England representative, with offices at 210 Capitol National Bank building, 410 Asylum street, Hartford, Conn.

♦

Recent appointment of two new sales representatives in the Eastern district has been made by The McKenna Metals Co., Latrobe, Pa. Operating under J. A. Deakin Sr., eastern sales manager, 50 Church street, New York, the two representatives are: R. S. Hudgins who will be located at 965 Farmington avenue, West Hartford, Conn., and Charles E. Washburn with offices at 258 Park Square building, Boston.

♦

According to an announcement by J. E. N. Hume, commercial vice president of General Electric Co., F. W. McChesney and Neal L. Parker of the industrial department have been made assistant managers of sales of the industrial manufacturers section, and of the machinery manufacturers section, respectively.

♦

Porcelain Enamel institute is now located at 919 New York avenue, Northwest, Washington, D. C., having moved recently from Chicago.

♦

Announcement was recently made by General Controls Co., Glendale, Calif., of the appointment of L. E. Wetzell as manager of the company's Cleveland branch office, located at 1505 Broadway. Mr. Wetzell has for several years been actively engaged in sales engineering work for the company. In his new position he will have complete charge of sales and service in Ohio, West Virginia, portions of Pennsylvania, Kentucky and Western New York.

♦

J. D. McKnight, after six years of sales experience with Allegheny-Ludlum Steel Corp., has been named assistant district manager at the company's Detroit office.

♦

Chairman of the board of directors of the General Electric Co., Philip D. Reed will head the industrial branches in the division of industry operations of WPB.

♦

Appointment of Martin Eliason as representative of the Jessop Steel Co., Washington, Pa., in the Milwaukee territory, with offices located at 419 Colby Abbot building, has been made. Mr. Eliason was formerly connected with the company's Chicago branch.

♦

To aid war effort, the latest in a series of conservation moves instituted during the past year by

Allegheny Ludlum Steel Corp. was made in the creation of a new scrap and salvage department which will be located at the company's Brackenridge, Pa., plant.

♦

With headquarters at 610 Continental building, Dallas, Tex., F. D. Carroll has been appointed district sales manager in this territory for Youngstown Sheet & Tube Co., Youngstown, O.

♦

Following his resignation as mechanical engineer of the Railway Steel Spring division of American Locomotive Co., Bennett Burgoon Jr. has joined the McKenna Metals Co. as representative at Rockford, Ill.

♦

Succeeding the late Walter C. Mack, Frank A. Stivers has been elected president of Hoover Ball Bearing Co., Ann Arbor, Mich. Mr. Stivers has been first vice president of the company since its organization in 1913.

♦

Previously assistant metallurgist of the Pittsburgh works of Jones & Laughlin Steel Corp., E. K. Waldschmidt has joined the cold finished sales department of the company.

♦

Formerly with Steel & Tubes division of Republic Steel Corp. in the Cleveland sales office and more recently with the Philadelphia district sales office, James S. Anderson has joined the New York district sales office of Babcock & Wilcox Tube Co., 85 Liberty street, New York.

♦

Andrew Thompson is the new manager of the Boston branch of Hewitt Rubber Corp., Buffalo, replacing Fred G. Phillips who has retired after 36 years of service.

♦

John R. Hoover, former manager of rubber-lined equipment sales for B. F. Goodrich Co., Akron, O., now becomes manager of synthetic sales for the company.

♦

New addition to the Tyson Roller Bearing Corp., Massillon, O., plant is now under way. The new building, an extension of the present plant, is a unit of the Victory program of the company. Under full-speed construction, it is anticipated the addition will be completed by April 1.

♦

Headquarters for the new Eastern sales division of The Sawyer Electrical Mfg. Co., Los Angeles, will be at 2110 Terminal Tower, Cleveland, with George M. Snodgrass as manager. The company manufactures a line of special electric motors for machine tools as well as rotors and stators for built-in applications.

♦

Two promotions and an addition to the organization of the International Resistance Co., 401 North Broad street, Philadelphia, have been made. Formerly assistant manager of the company's industrial division, Harold G. Beebe now becomes manager of this division. Robert Elmore, a newcomer, will assist Mr. Beebe in industrial division sales and engineering work.

♦

Address of the Chicago district office of The Copperweld Steel Co., Warren, O., will be 122 South Michigan avenue. R. S. Clingan is the Chicago district manager in charge of the company's Aristoloy alloy steels.

Meetings and Expositions

March 10-13—

American Society of Bakery Engineers. Annual meeting to be held at Edgewater Beach hotel, Chicago. Victor E. Marx, 1541 Birchwood avenue, Chicago, is secretary.

March 17-19—

American Railway Engineering association. Annual meeting to be held at Palmer House, Chicago. W. S. Lacher, 59 East Van Buren street, Chicago, is secretary.

March 23-25—

American Society of Mechanical Engineers. Spring meeting to be held at Rice hotel, Houston. C. E. Davies, 29 West 39th street, New York, is secretary.

March 26-28—

American Society of Tool Engineers. Annual meeting to be held at Hotel Jefferson, St. Louis. Clyde L. Hause, 2567 W. Grand boulevard, Detroit, is national secretary.

April 15—

Packaging Machinery Manufacturers institute. Semi-annual meeting to be held at Hotel Astor, New York. H. L. Stratton, 342 Madison avenue, New York, is secretary.

April 16-17—

National Petroleum association. Semiannual meeting to be held at Cleveland hotel, Cleveland. M. C. Mallon, 930 Munsey building, Washington, is secretary.

April 20-24—

American Foundrymen's association. Forty-sixth annual convention and exhibition to be held at Public Auditorium and Exhibition hall, Cleveland. R. E. Kennedy, 222 Adams street, Chicago, is secretary.

April 20-24—

American Chemical Society. Spring meeting to be held at Hotel Peabody, Memphis. C. L. Parsons, 1155 Sixteenth street, Washington, is secretary.

April 22-24—

Petroleum Industry Electrical association. Annual meeting and exhibition to be held at the Washington-Youree hotel, Shreveport. J. F. Collerain, P. O. Box 2412, Houston, is secretary.

April 27-28—

Association of Iron and Steel Engineers. Spring conference to be held at the Royal Connaught hotel, Hamilton, Ont., Canada. J. L. Miller, Empire building, Pittsburgh, is secretary.

April 27-May 1—

American Mining Congress. Nineteenth annual coal convention and exposition to be held in Cincinnati. J. D. Conover, Munsey building, Washington, is secretary.

May 4-6—

American Supply and Machinery Manufacturers' association. Convention to be held at Hotel Traymore, Atlantic City. R. Kennedy Hanson, 1108 Clark building, Pittsburgh, is general manager.

May 10—

National Electrical Manufacturers association. Annual meeting to be held at The Homestead, Hot Springs. R. J. Blais, 155 East 44th street, New York, is convention manager.

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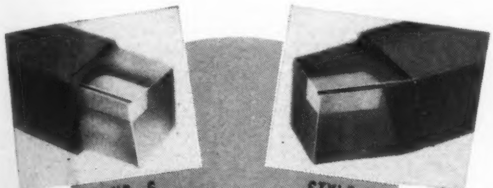

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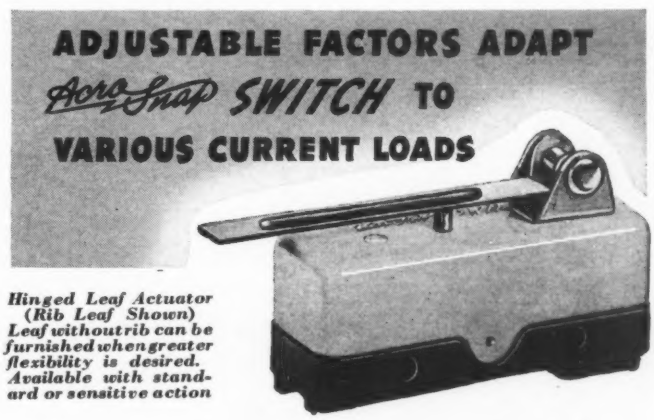

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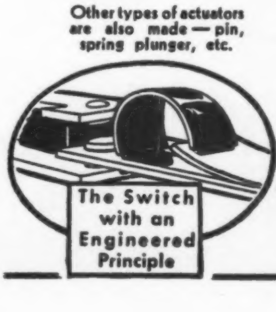

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Water-type dust collector, Newcomb-David Co., Detroit.
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Compressor, Schramm Inc., West Chester, Pa.
Commercial and industrial stoker, Frederick Iron & Steel Co., Frederick, Md.
Hand-operated pump metering unit, Blackmer Pump Co., Grand Rapids, Mich.
Shop truck, The Buda Co., Harvey, Ill.
Wire rope electric hoist, Wright Mfg. Div., American Chain & Cable Co. Inc., Bridgeport, Conn.

Metalworking
Gap gage grinding machine, Ny-Lint Tool Co., Rockford, Ill.
Double-end carbide tool, Willey's Carbide Tool Co., Detroit.
Hydraulic plate bending press, Lake Erie Engineering Corp., Buffalo, N. Y.
Belt grinder, Porter-Cable Machine Co., Syracuse, N. Y.
Production-type miller, C. C. Bradley & Son Inc., Syracuse, N. Y.
Vertical automatic chucker, Nylen Products Co., St. Joseph, Mich.
Rifle barrel recentering machine, W. M. Steele Co., Worcester, Mass.
Feeding and straightening machine, F. J. Litell Machine Co., Chicago.
Dual-ram broacher, Colonial Broach Co., Detroit.
Turret lathe, G. M. Diehl Machine Works, Wabash, Ind.
Double-end burring machine, Pines Engineering Co. Inc., Batavia, Ill.
Power squaring shears, Niagara Machine & Tool Works, Buffalo, N. Y.
Wide-swing grinder, The Hisey-Wolf Machine Co., Cincinnati.
Lathes of 12, 14 and 16-inch capacities, Bradford Machine Tool Co., Cincinnati.

Automatic machine for pinions, shafts, etc., The Wickman Corp., Detroit.
Production-type shaper, General Engineering & Mfg. Co., St. Louis.
Wire cable weaving machine, W. A. Hudson Boiler & Welding Co., Chicago.
Straightening press, The Watson-Stillman Co., Roselle, N. J.

Packaging

Large-sized package bundling machine, Package Machinery Co., Springfield, Mass.
Carton sealer, Felton & Son Inc., South Boston, Mass.
Cottage cheese cup filling machine, Ata Mfg. Co. Inc., New Haven, Conn.
Motorized sealer, Minnesota Mining & Mfg. Co., St. Paul.

Quarry

Crushing plant, The Austin-Western Road Machinery Co., Aurora, Ill.
All-steel ore and rock crusher, Allis-Chalmers Mfg. Co., West Allis, Wis.
Roll crusher, Diamond Iron Works Inc., Minneapolis.

Restaurant

Midget dough roller, Anetsberger Bros., Chicago.
Sectional automatic heat controlled griddle, Associated Products Inc., Akron, O.
All-electric steakmaker, Federal Engineering Co., Minneapolis.

Rubber

Horizontal hose reinforcement machine, Fidelity Machine Co., Philadelphia.

Textile

Rayon ring twister, H & B American Machine Co., Pawtucket, R. I.
Two-roll padder, H. W. Butterworth & Sons Co., Philadelphia.
Brushing machine, Hermas Machine Co., Hawthorne, N. J.
Infra-red ray dryer, Infra Red Equipment Corp., Chicago.
Piece-dye kettle, James Hunter Machine Co., North Adams, Mass.
Sewing machine, Wilcox & Gibbs Sewing Machine Co., New York.